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EPHEMERIS DATA

CORRJPL

3 tapes

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EPHEMERIS DATA

CORRJPL

This data set consists of 3 tapes containing Ephemeris information for all the planets and the Moon. The tapes were created on a UNIVAC 1108 computer and are 800 BPI, 7-track, binary with one file per tape.

The format for the data can be found on page 23 of the 'JPL Development Ephemeris Number 69, Technical Report 32-1465', which is included in this data set catalog.

The first record of each tape is a BCD header describing the general nature of the information on the tape. The first and last words of each record are control words which are not mentioned in the format.

The time spans for the tapes are as follows:

<u>D#</u>	<u>C#</u>	<u>TIME SPAN</u>
D-11597	C-09569	6/24/52 - 4/20/70
D-11598	C-09570	3/05/70 - 4/03/84
D-11599	C-09571	1/13/84 - 11/30/99

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report 32-1465

JPL Development Ephemeris Number 69

Douglas A. O'Handley

Douglas B. Holdridge

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CALIFORNIA INSTITUTE OF TECHNOLOGY
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Preface

The work described in this report was performed by the Mission Analysis Division of the Jet Propulsion Laboratory.

Acknowledgment

The system of computer programs used in this research effort were formulated by Dr. Charles C. Lawson of JPL. The system analysis and coding was carried out by the Federal Systems Division West of International Business Machines Corporation.

In particular, two individuals Rex E. Reed and Dan Dannenfeldt of IBM are singled out for their interest and dedication in the successful implementation of the system of programs to improve the knowledge of the locations of planets in the solar system.

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Abstract

The third issue of JPL Ephemeris Tapes is described, and is designated JPL Development Ephemeris No. 69 (DE 69). It is a special-purpose ephemeris that covers a short time span and does not replace DE 19 (Ref. 1) as the JPL export ephemeris. These tapes carry the positions and velocities of the planets and of the moon, nutations and nutation rates in longitude and obliquity, and second and fourth modified differences of all these quantities for the interval from October 28, 1961 to January 23, 1976. The description includes discussions of the improvements in the Lunar Ephemeris and the planetary ephemerides made subsequently to the second issue of the JPL Ephemeris Tapes (DE 19). These tapes will be distributed through the NASA Computer Software Management and Information Center (COSMIC).

JPL Development Ephemeris Number 69

I. Introduction

The JPL Development Ephemeris 69 described in this report is the third release from the JPL Ephemeris Tape System. It is a special purpose ephemeris that covers a short time span and will not replace DE 19 (Ref. 1) as the JPL Export Ephemeris. For users who need planetary positions before 1962 and after 1976, the DE 19 ephemeris is still available.

Tape	Julian date (Calendar date)	to	Julian date (Calendar date)
DE 69	243 7600.5 (1961 Oct. 28.0)	244 2800.5 (1976 Jan. 23.0)	

This ephemeris is the first gravitationally consistent ephemeris computed and exported from JPL. The computations are carried out by a system of programs referred to as the Solar System Data Processing System (SSDPS). The numerical integration, the observational data set, and comparison of these data with the simultaneous integrations of the nine planets are discussed.

The lunar data in DE 69 were not produced by the SSDPS integration, but are nonetheless quite different from those of DE 19. These data are the result of a composite process that included a long-span numerical integration of the moon only. The construction process is discussed in some detail in the following section.

Planetary data are heliocentric and are expressed in astronomical units (AU) and AU/day, and lunar data are geocentric and expressed in fictitious units called "earth radii" (R_{em}) and "earth radii"/day. Translation between the geocenter and the earth-moon barycenter is accomplished using the earth/moon mass ratio μ^{-1} . The values of these parameters currently recommended for most satisfactory use of DE 69 are (Ref. 2) as follows:

$$AU = 149,597,893.0 \quad km$$

$$R_{em} = \quad 6378.1492 \quad km$$

$$\mu^{-1} = \quad 81.301$$

Master copies of DE 19 and DE 69 have been supplied to COSMIC, University of Georgia, which will serve as the primary distribution point for these data.

II. Lunar Ephemeris

The requirements of high-precision analysis of space-craft data and the accurate determination of the coordinates of DSN tracking stations have been major motivating factors in the persistent efforts to improve the quality of the JPL lunar ephemerides. Residual characteristics have sometimes suggested problem areas and potential improvement techniques. It is just such a situation that led to the development of JPL Lunar Ephemeris Number 16.

A. Background

It has been noted for some time that the tracking station locations derived from analyses of planetary space-craft data differ systematically from the locations of the same stations based on data from lunar missions, the differences being on the order of tens of meters. This circumstance has been difficult to understand. If it were attributed to errors in the Lunar Theory, or in its fitting to observations, the size and nature of the error would make it easily observable. On the other hand, the proliferation of coordinate systems in astronomy presents a more subtle pitfall. Van Flandern (Ref. 3) pointed out that, for the fitting of the Lunar Theory to observations, E. W. Brown determined the equinox from his own reference stars. Thus, the reference direction of the theory is unique to that theory; it is apparently very near to Newcomb's equinox. To be consistent with the planetary ephemerides based on modern observations, the lunar ephemeris should be referred to the FK4 coordinate system (Ref. 4). It seems safe to assume that virtually all users of the JPL Ephemeris Tape System have, from its inception, tacitly assumed that this was the case. This must be regarded as an error in the precepts for application of the ephemeris rather than in the ephemeral data themselves. Nonetheless, the transformation to the FK4 model should be done in the Ephemeris Tape System, if the necessary parameters are known.

Van Flandern has, in fact, undertaken to solve for the transformation between Brown's equinox and that of the FK4, as a part of a more general study to correct the lunar elements. A very preliminary discussion of this effort is given in Ref. 3, and a complete solution is presented in Ref. 5. These latter results were not the final results of the work; some of the values have changed subsequently, but the equinox shift has remained fairly stable throughout the work. However, the coupling between parameters is such that the equinox shift so derived should be applied as a part of the overall system.

B. Transforming the JPL Ephemeris

This entire question will vanish when the lunar ephemeris is based on a numerical integration fit to real observations referred to the FK4 frame. This work is underway, but may not be expected to produce operationally useful results for some time yet. Nonetheless, previously reported work (e.g., Ref. 6) has indicated the urgent need for an integrated lunar ephemeris for operational use, and it seems desirable that it be on the FK4 system if possible.

The problems involved in producing long-interval integrations of the lunar motion were discussed in Ref. 7, where the effects not modelled in a PLOD integration (Ref. 8) were described, as was a theoretical ephemeris (LE 13) which had these effects removed analytically. In attempting to place such an ephemeris on the FK4 system, no alternative currently exists but the application of the results in Ref. 5. The corresponding expressions to be applied to a theoretical ephemeris were supplied by Van Flandern and these were applied to LE 12. The effect of the equinox shift was to change the mean longitude by an amount

$$\Delta L = -0.^{\circ}8746 + 0.^{\circ}732T$$

T in centuries from 1950. It may be presumed that this ephemeris (LE 14) is on the FK4 system, contains none of the effects known to be unmodelled in PLOD, and suffers the gravitational defects of the Brown theory. This was used as a source theory to which a PLOD numerical integration was fit over the interval 1950–1970. The statistics of the fit are given in Table 1, where the ephemeris is designated LE 15. This ephemeris does not have the gravitational defects of the Brown theory, but cannot be used directly because of the effects unmodelled in the integration, the effects that were removed analytically in the construction of LE 12. Thus, it was necessary to replace them; this was done by analytic modifications applied to the coordinates of LE 15. This

Table 1. Statistics of the fit of LE 15 to LE 14

Coordinate	δr	$r \cos \beta \delta \lambda$	$r \delta \beta$
Mean deviation	+64.2 m	-0.2 m	-4.8 m
Standard deviation	223.8	211.4	249.5
Extremal deviation	+851.4	+757.7	-758.8

last step in the sequence was designated LE 16¹, which should fit Van Flandern's version of the Brown theory in the same way that LE 15 fits LE 14. A sample comparison of LE 16 with LE 4 (Ref. 9), which is in DE 19, is given in Fig 1.

Because of the interest in the station location problem, and of the insensitivity of the *Mariner* trajectory to such small changes in the lunar ephemeris, LE 16 was incorporated into DE 69, the operational ephemeris for *Mariner* Mars 1969 pre-encounter activities. It is not yet clear how much of an improvement the equinox shift has produced, but station location analyses by other JPL investigators (Refs. 10 and 11) indicate that spacecraft trajectory residuals are reduced by use of LE 16. Although consistency between lunar and planetary mission results has not yet been achieved unambiguously, the disparities

¹This discussion presents some insight into the proliferation of LE and DE numbers in the ephemeris development effort. Each distinct ephemeris receives a number, to minimize possible confusion. In this case, LE 12, 14 and 15 will never be used operationally, but they were necessary steps in the construction of LE 16.

are reduced in most cases. The initial tests of the application of real observations of the moon have also been encouraging. The lunar starting conditions for a ten-body integration were taken from LE 16 and, while the integration and comparison with observations covered only 100 days, an equinox error would appear as a roughly constant bias in right ascension. None was observed as large as a few tenths of an arc second.

III. Planetary Ephemeris

A. Numerical Integration

The current JPL Export Ephemeris, DE 19 (Ref. 1), consists of nine successive single-body integrations. The relativistic differential equations of motion used in this integration were based upon the Schwarzschild line element which is given in Brouwer and Clemence (Ref. 12).

The SSDPS was completed late in 1967. It is a series of programs that is used to integrate numerically the motions of the nine planets simultaneously, compare

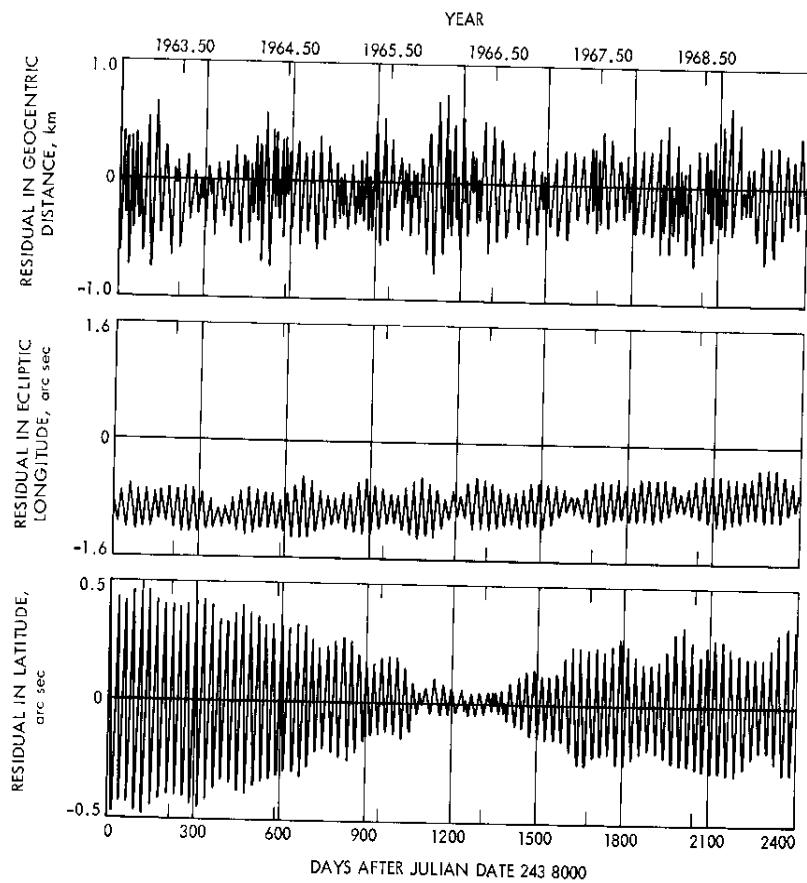


Fig. 1. Effects of TVF corrections—LE 16—LE 4.

with optical, radar, and spacecraft observations, form partial derivatives with respect to the orbital elements and additional parameters, and provide corrections to the initial set of osculating elements and parameters.

The heliocentric equations of motion are:

$$\ddot{\underline{r}}_j = -(w_o + w_j) \underline{u}_j - \sum_{\substack{i=1, 10 \\ i \neq j}} w_i (\underline{v}_{ij} - \underline{u}_i) + \underline{R}(\underline{r}_j, \dot{\underline{r}}_j, m_j)$$

where

$$\underline{s}_{ij} = \underline{r}_j - \underline{r}_i$$

$$\underline{u}_j = r_j^{-3} \underline{l}_j$$

$$\underline{v}_{ij} = s_{ij}^{-3} \underline{s}_{ij}$$

$$w_j = Gm_j \text{ where } G = (0.01720 20989 5)^2$$

$$w_o = G$$

The function \underline{R} is used to introduce the effects associated with general relativity.

In order to be compatible with the form of the relativity metric used in the double-precision orbit determination program (DPODP), the SSDPS used the "Robertson" form of the metric (Ref. 13). The Robertson parameters β and γ are now input quantities with the nominal values of unity. With these values, the equations reduce to the isotropic form of the metric.

The vector transformation, relating standard form coordinates r to isotropic coordinates ρ , is

$$r = \rho \left(1 + \frac{m}{2\rho} \right)^2.$$

This transformation, together with its first time derivative, must be used to convert the new isotropic coordinates and velocity components in DE 69 to the standard Schwarzschild metric used in DE 19. Here, m is the Schwarzschild radius.

$$m = 1.47 \text{ km}$$

The values of the Sun/planet mass ratios have been altered from those appropriate for DE 19. In DE 19 the planetary masses were identical with the internationally adopted set [(IAU), 1964] and are given in the first column of Table 2. The planetary masses used in the 60-year integration reflect more recent determinations (Ref. 2).

Table 2. Reciprocal planetary masses

Planet	IAU (1964)	JPL (1969)
Mercury	6 000 000	5 983 000
Venus	408 000	408 522
Earth-moon	329 390	328 900.1
Mars	3 093 500	3 098 700
Jupiter	1 047.355	1 047.3908
Saturn	3 501.6	3 499.2
Uranus	22 869	22 930
Neptune	19 314	19 260
Pluto	360 000	1 812 000
Sun = 1.0.		

The mass of Mercury is derived from analysis of radar observations of Venus. The mass values used for Venus, Earth-moon and Mars are based on radio tracking data from the Mariner, Ranger and Surveyor spacecraft series. The masses of Jupiter, Saturn, and Uranus result from the rediscussion by Mulholland (Ref. 14). The masses of Neptune and Pluto result from more recent work by Gill and Gault (Ref. 15) and Duncombe, et al., respectively (Ref. 16). These masses are given in column 2 of Table 2.

The epoch conditions for DE 69 are referred to JD 244 0800.5, O^hET, August 2, 1970. This date has been chosen as the standard 400-day date in 1970 which will be used by the ephemeris group of representatives from NASA, the U. S. Naval Weapons Laboratory (NWL), the U. S. Naval Observatory (USNO), and JPL.

B. Observation Set

Optical observations from 1910–1968 from the Six and Nine Inch Transit Circles of the USNO have been collected and placed in a uniform format on punched cards (Ref. 17). The collection of the data over the period 1911–1949 was made by C. Oesterwinter (NWL), Dahlgren, Virginia. These observations were initially compared with DE 28 (Ref. 18). The mispunched cards and obvious printing errors were found and corrected. The final optical data set of over 34,000 observations covering the 60-year period is given in Table 3.

Radar range data from various radar sites have been collected. The collection of these data has been a joint effort by MIT-Lincoln Laboratory and JPL.

Table 3. Transit circle observations

Planet	USNO transit circle	Period	Number of observations	
			Right ascension	Declination
Mercury	6 in. 9	241 9937.2-243 9654.3 (1913-1967)	1756	1695
		242 1867.2-243 1174.2 (1918-1944)	550	532
			2306	2227
Venus	6 9	242 0391.3-243 9679.3 (1914-1967)	2761	2582
		242 2113.3-243 1129.1 (1919-1944)	451	436
			3212	3018
Mars	6 9	242 4793.8-243 9658.5 (1926-1967)	549	528
		242 0105.8-243 1164.5 (1913-1944)	122	120
			671	648
Jupiter	6 9	242 4311.8-243 9548.6 (1965-1967)	656	624
		242 0330.8-243 1165.6 (1914-1944)	260	257
			916	881
Saturn	6 9	242 4607.8-243 9433.6 (1926-1966)	660	622
		242 0085.8-243 1122.6 (1914-1944)	280	280
			940	902
Uranus	6 9	243 4380.8-243 9595.6 (1925-1967)	639	628
		242 0321.8-243 1061.7 (1914-1943)	247	245
			886	873
Neptune	6 9	242 4531.8-243 9662.6 (1925-1967)	618	606
		242 0129.8-243 1214.6 (1913-1944)	285	283
			903	889
Sun	6 9	241 9174.2-243 9682.2 (1911-1967)	5973	5695
		242 1867.2-243 1444.2 (1918-1944)	1696	1668
			7669	7363

The current ephemeris can predict the position of Venus to better than 20 μ s in range. It has been found that the inclusion of Arecibo Ionospheric Observatory (AIO) data degrades this ephemeris. A systematic bias of approximately 30 μ s appears in the residuals. Consequently, most AIO data have been removed from the data set pending re-examination of these data which is currently under way at AIO. The data set used in this development ephemeris is given in Table 4. This radar datum is also placed in a uniform format on punched cards (Ref. 17).

The first use of spacecraft data in ephemeris development is under way with the 60-year ephemerides. A total of 214 planetary range points covering the period June 21 to November 12, 1967 from the R&D planetary ranging system on *Mariner V* were used. These points are of 0.1 μ s accuracy. Through the perturbations by Venus on the orbit of *Mariner V* during the encounter phase, the center of gravity of Venus can be determined

at the time of encounter by *Mariner V* to 100 m in geocentric range and 5 m/day in geocentric range rate².

C. Ephemeris Computations

In the spring of 1968, the first simultaneous integration of all the planets was made at JPL. The initial conditions were close to those found in DE 19. These DE 19 initial conditions resulted from individual numerical integrations of all the planets using the relativistic differential equations fit to either the source theories from the USNO, or the Newcomb theories as programmed by N. Block in 1963. The initial conditions of Venus and the earth-moon barycenter differ from DE 19. These improved initial conditions are from DE 26.³ These

²This assumes that the speed of light is given exactly by the IAU value of 299792.5 km/s.

³Lawson, C. L., "Announcement of JPL Development Ephemeris No. 26," Internal Document, Jet Propulsion Laboratory, Pasadena, Calif., June 7, 1967.

improved Venus and Earth-moon ephemerides resulted from comparison of the theories with optical observations from the 6-in. transit circle of the USNO between 1950 and 1965 and planetary radar from JPL, MIT, and AIO between 1961 and early 1967. A set of masses unlike those used in DE 19 or DE 69 were used (Ref. 14). The epoch conditions at JD 244 0400.5 were altered to reflect this change in planetary masses by constraining the osculating mean motions while adjusting the values for the semi-major axis. The expression

$$n^2 a^3 = k^2 (1 + m + \delta m)$$

was used. A forward integration was made to the chosen "standard epoch" 2440800.5. At this point, the integrated epoch conditions for 1970 were used to begin a 20-year backward integration.

The initial comparison with the combined set of planetary range data of AIO, the Millstone Hill and Haystack sites of MIT, and JPL's, Venus site showed variations which were quite large (see Figs. 2, 3, and 4) as follows:

- (1) +4000 to -2000 μ s for Mercury.
- (2) +1500 to approximately 0 μ s for Venus with a positive offset.
- (3) +3000 to -1000 μ s for Mars.

These radar residuals along with a set of USNO 6-Inch Transit Circle Observations over the period 1950-1967 were used to correct the orbital elements of all the planets except Pluto, along with the radii and the astronomical unit.

A 56-parameter solution was made using these data. A rank 52 solution of an eigenvalue-eigenvector analysis was applied to the original osculating elements and a new integration performed⁴. The magnitudes of the radar range residuals were reduced by two orders of magnitude.

This first gravitationally consistent ephemeris computed at JPL was used from the Spring of 1968 until February 1969. At the completion of this initial effort, it was known that the outer planets were improved over the currently available ephemerides, but also that there was a need to fit over a much longer arc in order to

⁴Lawson, C. L., "Eigenvalue-Eigenvector Analysis for SSDPS," Internal Report, Jet Propulsion Laboratory, Pasadena, Calif., Jan. 17, 1968.

Table 4. Radar range observations

Data source	Period	Number of observations
Mercury		
AIO	243 8493.2-243 9363.2 (1964-1966)	119
Haystack (MIT)	243 9425.3-244 0064.2 (1966-1968)	88
	Summary 1964-1968	207
Venus		
Haystack (MIT)	243 9161.3-244 0063.2 (1967-1968)	63
JPL (Venus DSS)	243 8541.2-243 9707.6 (1964-1967)	284
Millstone Hill (MIT)	243 8447.0-243 9725.2 (1964-1967)	101
	Summary 1964-1968	448
Mars		
AIO	243 8719.0-243 8915.0 (1964-1965)	39
Haystack (MIT)	243 9587.7-243 9643.5 (1967)	10
	Summary 1964-1967	49

obtain definitive ephemerides. Further, a longer arc of optical observations was needed to better determine the orientation of the ecliptic and the mean longitude of the earth-moon barycenter. Consequently, a 60-year numerical integration of the motion of the planets was made.

After a coordinate transformation to place the epoch conditions originally on the Schwarzschild metric into an isotropic form, a 60-year ephemeris was integrated. The interval of integration was from 1970 to 1910, and was designated DE 61.

A simultaneous solution of 63 parameters of the solar system was obtained reflecting the comparison of DE 61 with all the data discussed previously. The unknowns which are considered are the elements of the eight planets except Pluto, the right ascension and declination, limb bias for Mercury and Venus, the radii of Mercury, Venus, and Mars, the six elements of *Mariner V*, the mass of Venus, and the astronomical unit. After some consideration, a rank 55 solution from the eigenvalue-eigenvector analysis was selected for re-integration.

D. Comparison with Theory

The Mercury radar range residuals are shown in Fig. 5. These residuals are the result of the solution just discussed. The mean error for the fit of data is 57 μ s.

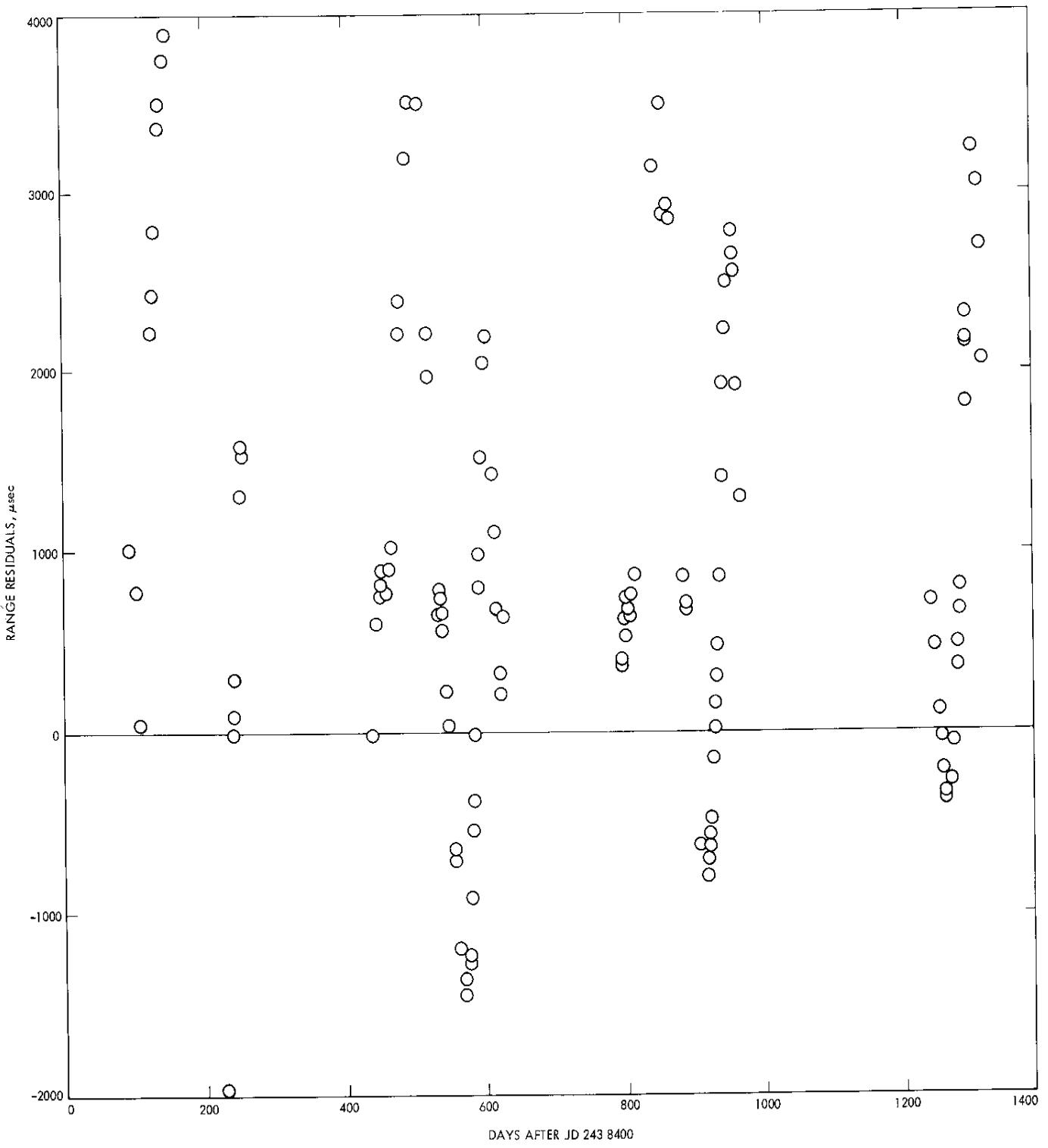


Fig. 2. Mercury radar range residuals with DE 35.

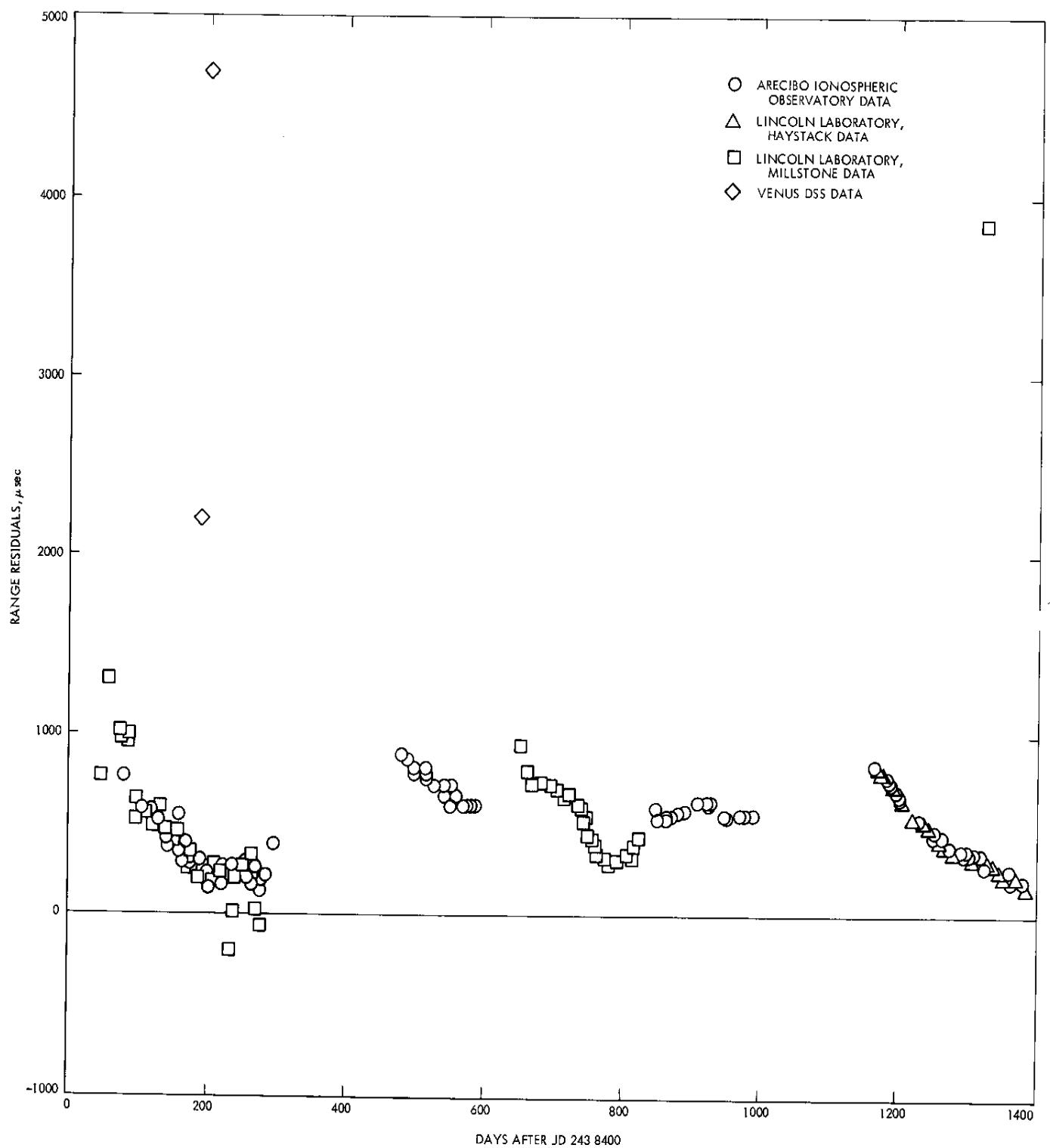


Fig. 3. Venus radar residuals with DE 35 (before fit).

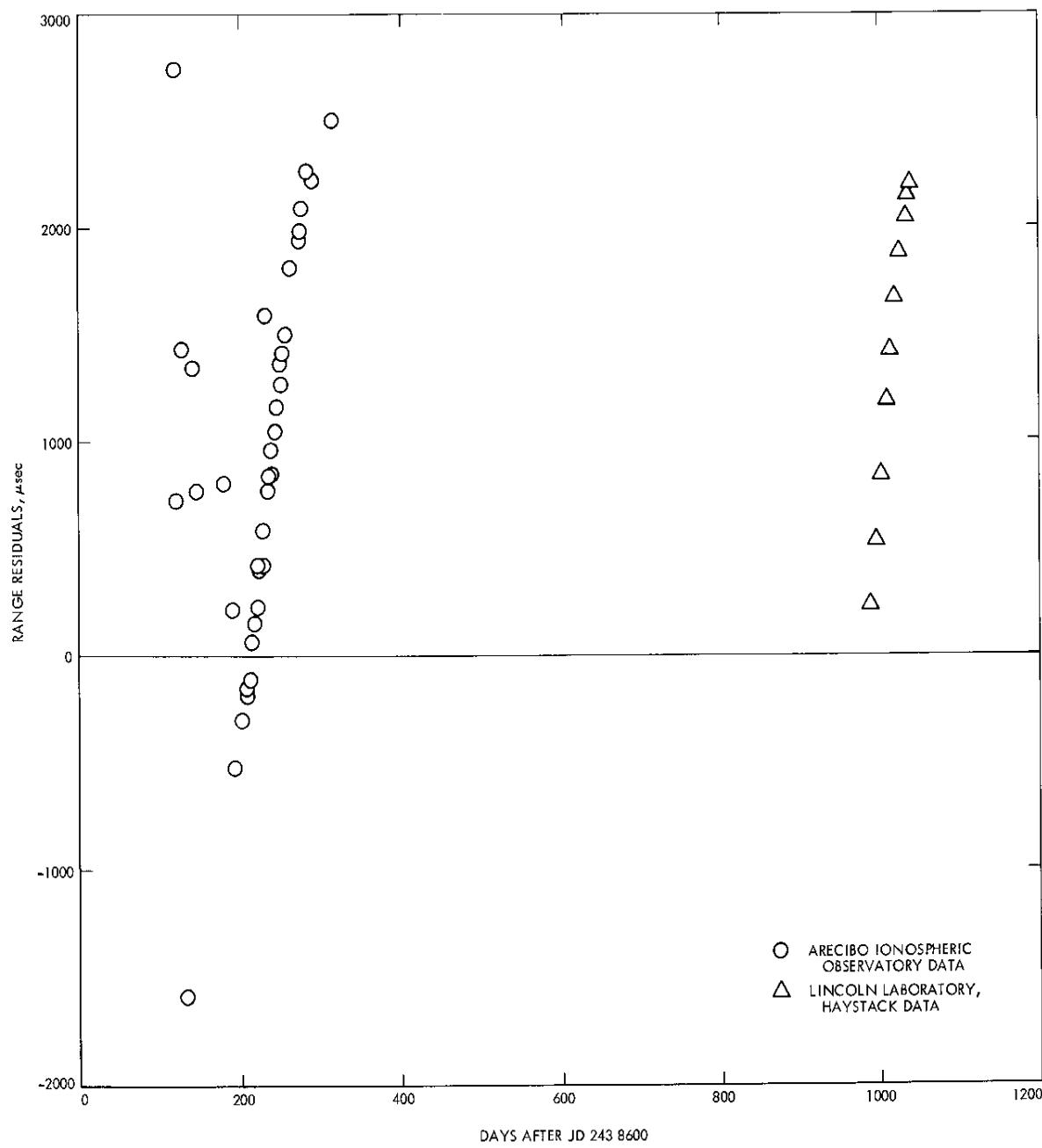


Fig. 4. Mars residuals compared with DE 35 (before fit).

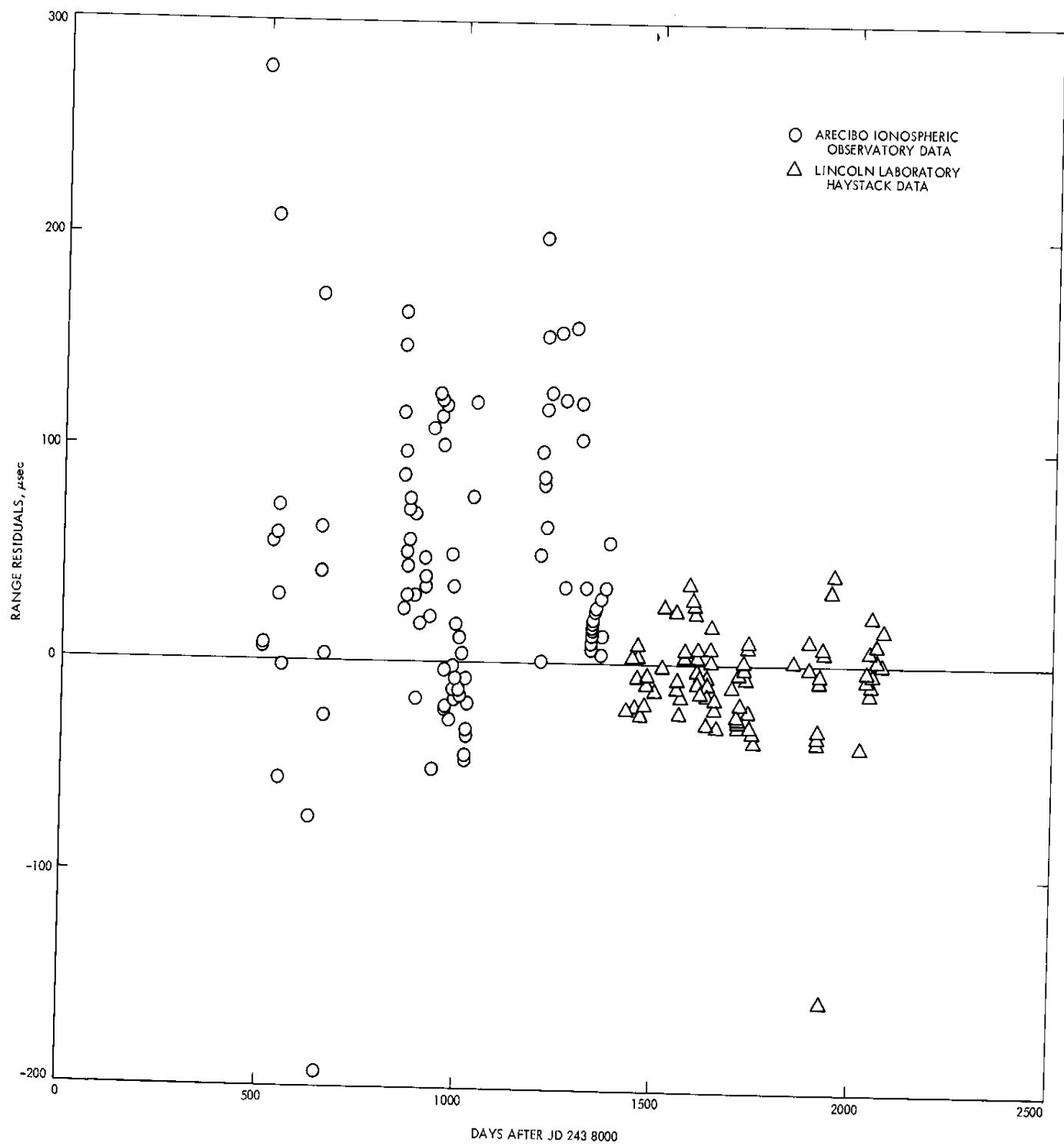


Fig. 5. Mercury radar range residuals—DE 69.

The increased radar detectability by the decreasing limits of radar residuals, as the data become more current, should also be noted. The standard deviations of the residuals on Mercury optical data are $1.^{\circ}0$ in right ascension and $0.^{\circ}9$ in declination.

Venus radar range data are from Millstone Hill, Haystack and JPL-Goldstone, the AIO data having been removed as a result of the previous discussions. The residuals based on DE 69 are shown in Fig. 6. The standard deviation for the fit of this data is $50 \mu\text{sec}$.

The structure to be seen in the 1965/1966 Venus radar range residuals must be regarded as an anomaly in the modeling of the masses. If one considers the masses better known from spacecraft tracking, and therefore fixes the values, the reduction of degrees-of-freedom will cause the "feature" to appear in the Venus residuals. By altering the mass of Mercury, the feature and the overall sum of squared residuals are diminished.

The structure in the 1967 Venus-residuals has been removed. It was caused by mis-identification of the time base of the measurements.

Figure 7 shows the *Mariner V* residuals with respect to the 60-year integration. The precision of this new data type is seen by the scale which is in tenths of microseconds.

The optical residuals of Venus in right ascension have a standard deviation of $1.^{\circ}2$ and in declination $0.^{\circ}9$.

The 39 radar observations of Mars taken in 1964 at AIO, and the 10 high-precision-compressed points taken at Haystack in 1967, are shown in Fig. 8 compared to DE 69. The standard deviation, excluding the few early points, is $50 \mu\text{s}$. The radar observations of Mars taken at JPL during the Spring and Summer of 1969 have not been included in DE 69.

The Sun and the planets, Jupiter, Saturn, Uranus, and Neptune, were fit to optical observations only. The residuals of the outer planets except Pluto are shown in Figs. 9 through 16. The periodic character of these residuals is indicative that further work is necessary on the planetary masses. Table 5 summarizes the statistics on the fit of the observations to DE 69.

In Appendix C are given all of the values to be used with DE 69. These reflect the solution just discussed.

Table 5. Statistics for fit of optical observations

Planet	Right ascension		Declination	
	Number of observations	Root mean square from mean	Number of observations	Root mean square from mean
1939-1967				
Mercury	913	.94	864	.93
Venus	1653	1.22	1504	.93
Mars	379	.52	360	.54
Jupiter	524	.45	498	.48
Saturn	509	.48	484	.53
Uranus	475	.33	465	.43
Neptune	519	.85	506	.60
Sun	3526	.76	3304	.60 ^a
1910-1939				
Mercury	1394	1.04	1363	.85
Venus	1559	1.22	1514	.92
Mars	292	.72	288	.62
Jupiter	392	.54	383	.56
Saturn	431	.50 ^a	416	.50 ^a
Uranus	411	.48	408	.51
Neptune	384	.56	383	.46
Sun	4143	.80 ^a	4059	.83

^aThese are estimated errors.

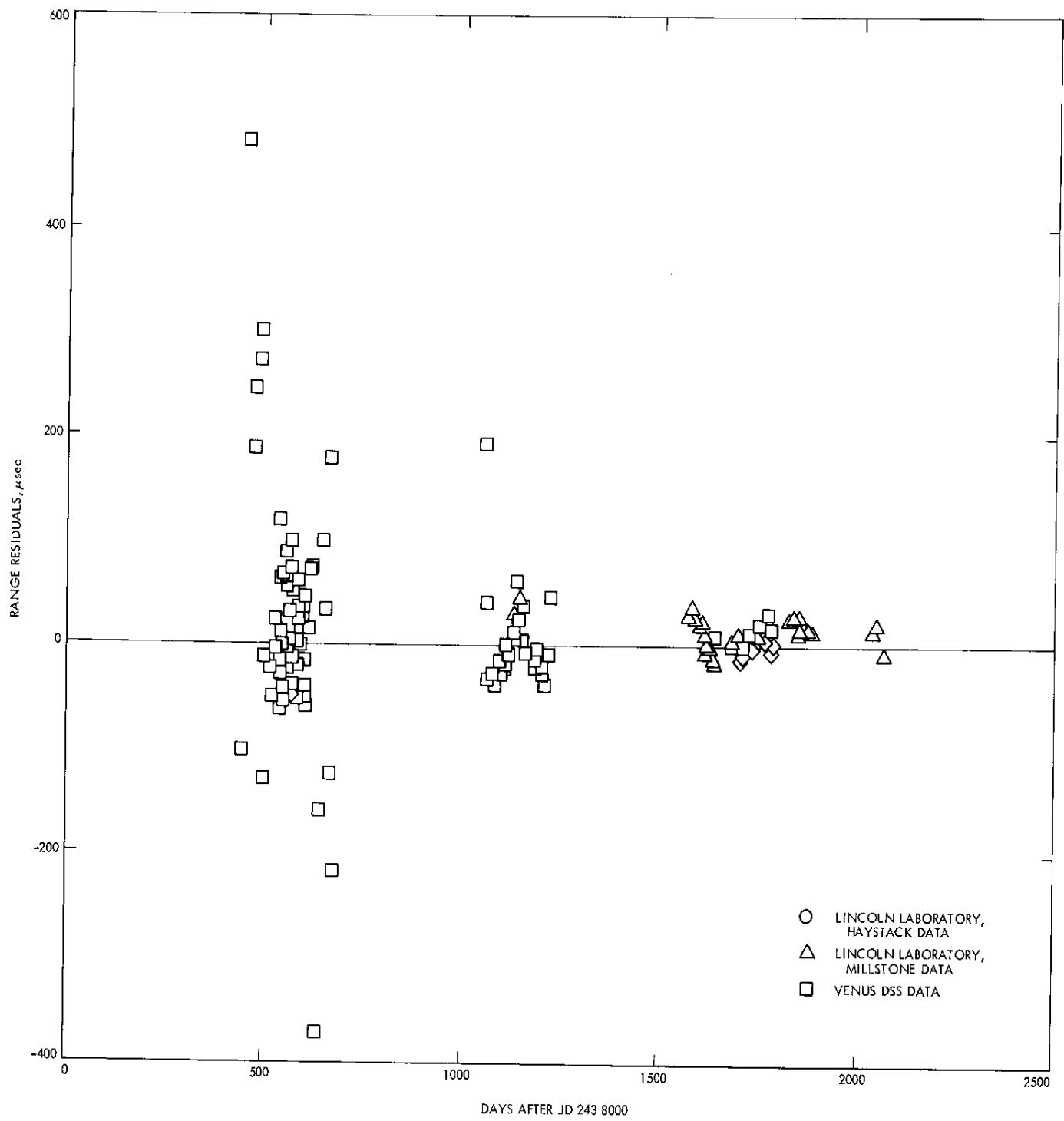


Fig. 6. Venus radar range residuals—DE 69.

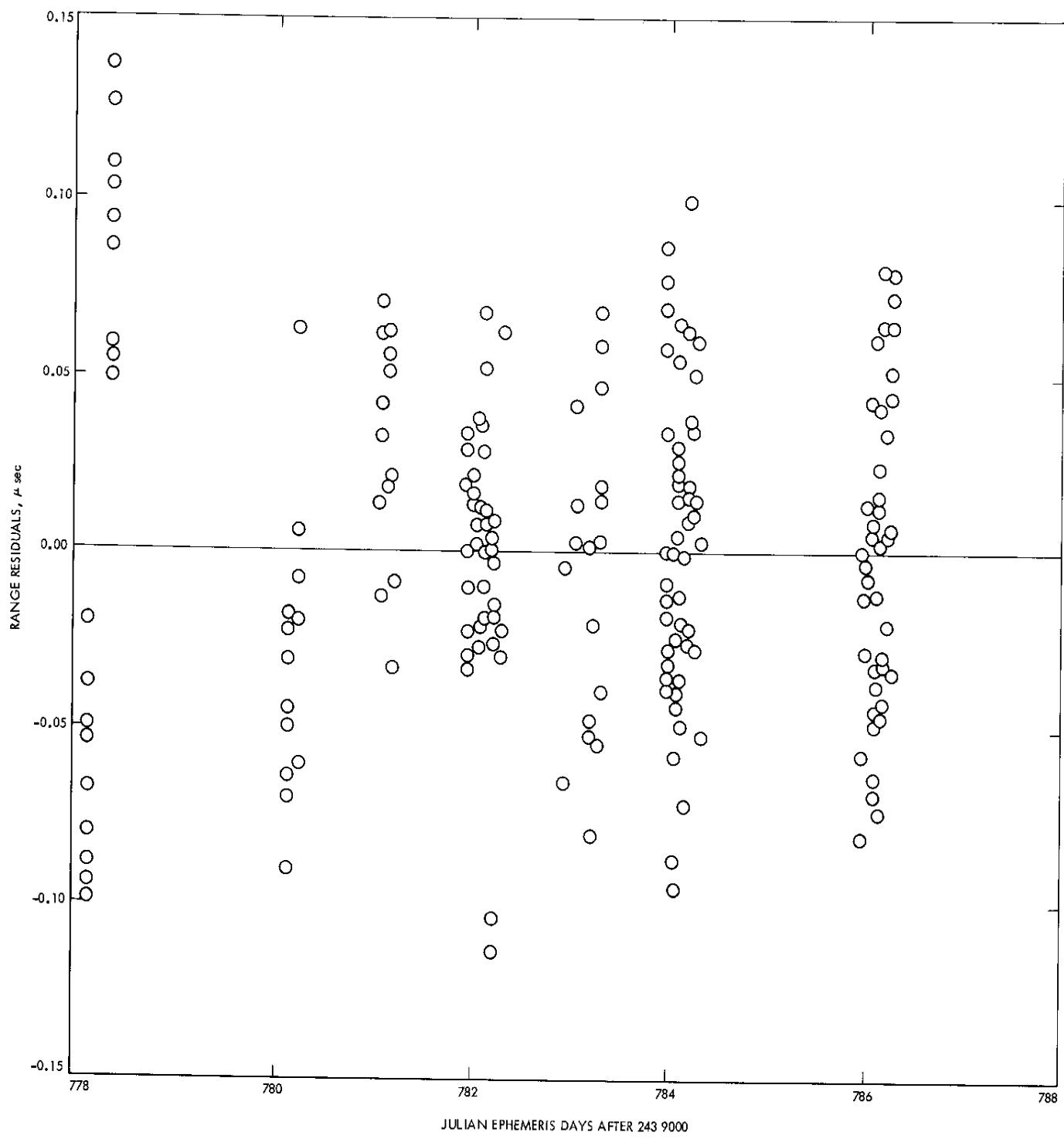


Fig. 7. Mariner V residuals.

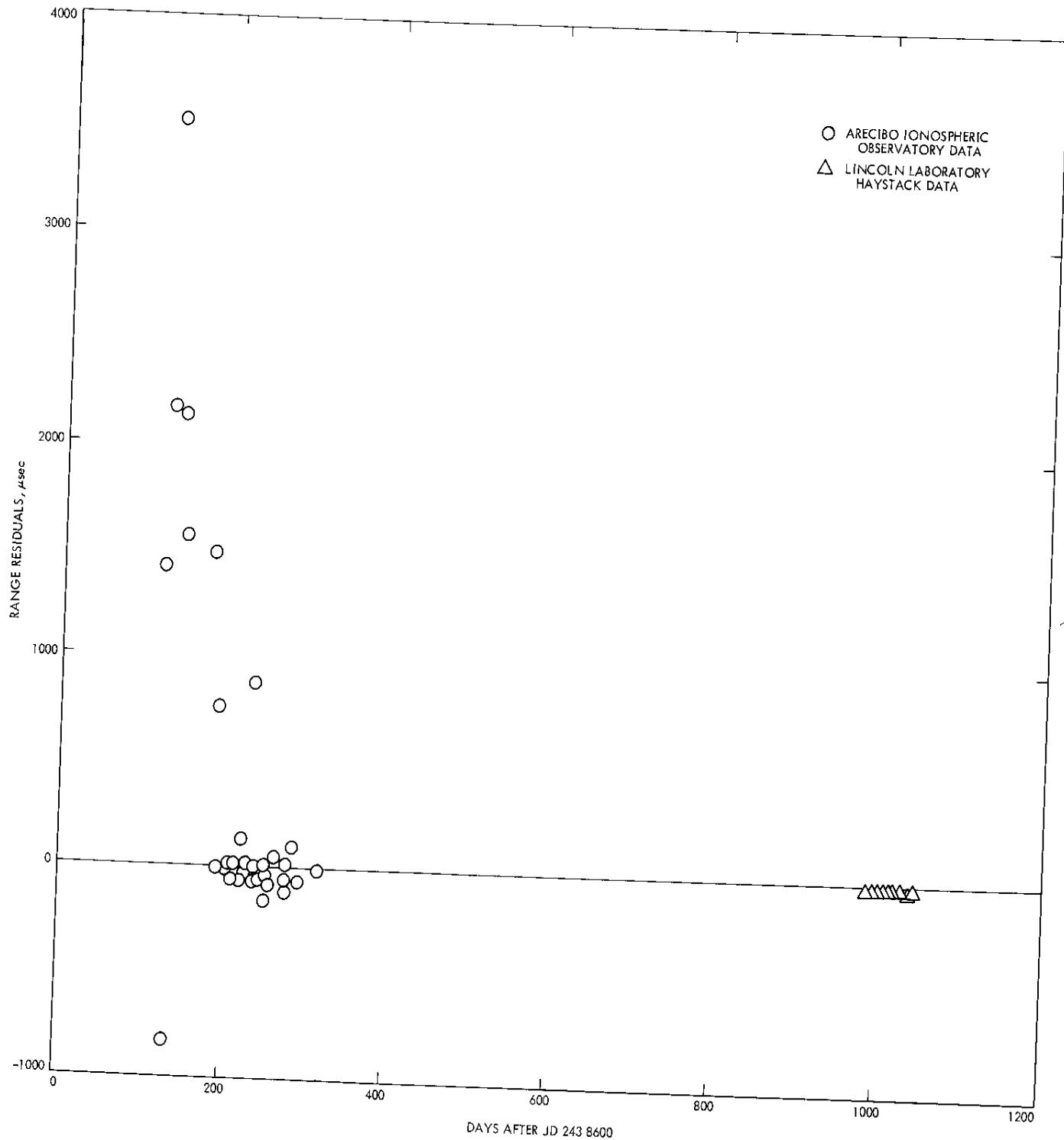


Fig. 8. Mars radar range residuals—DE 69.

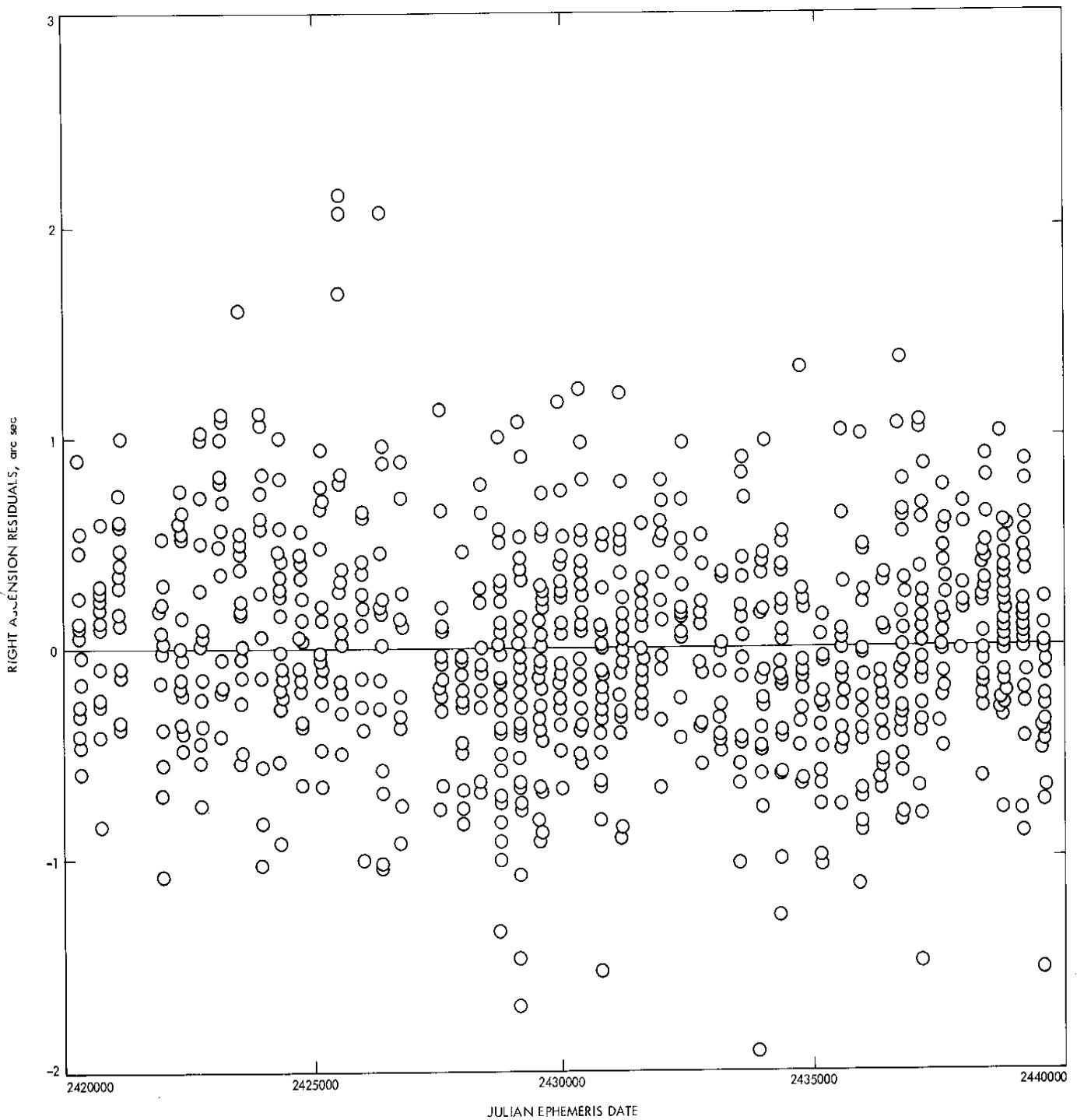


Fig. 9. Right ascension residuals—Jupiter.

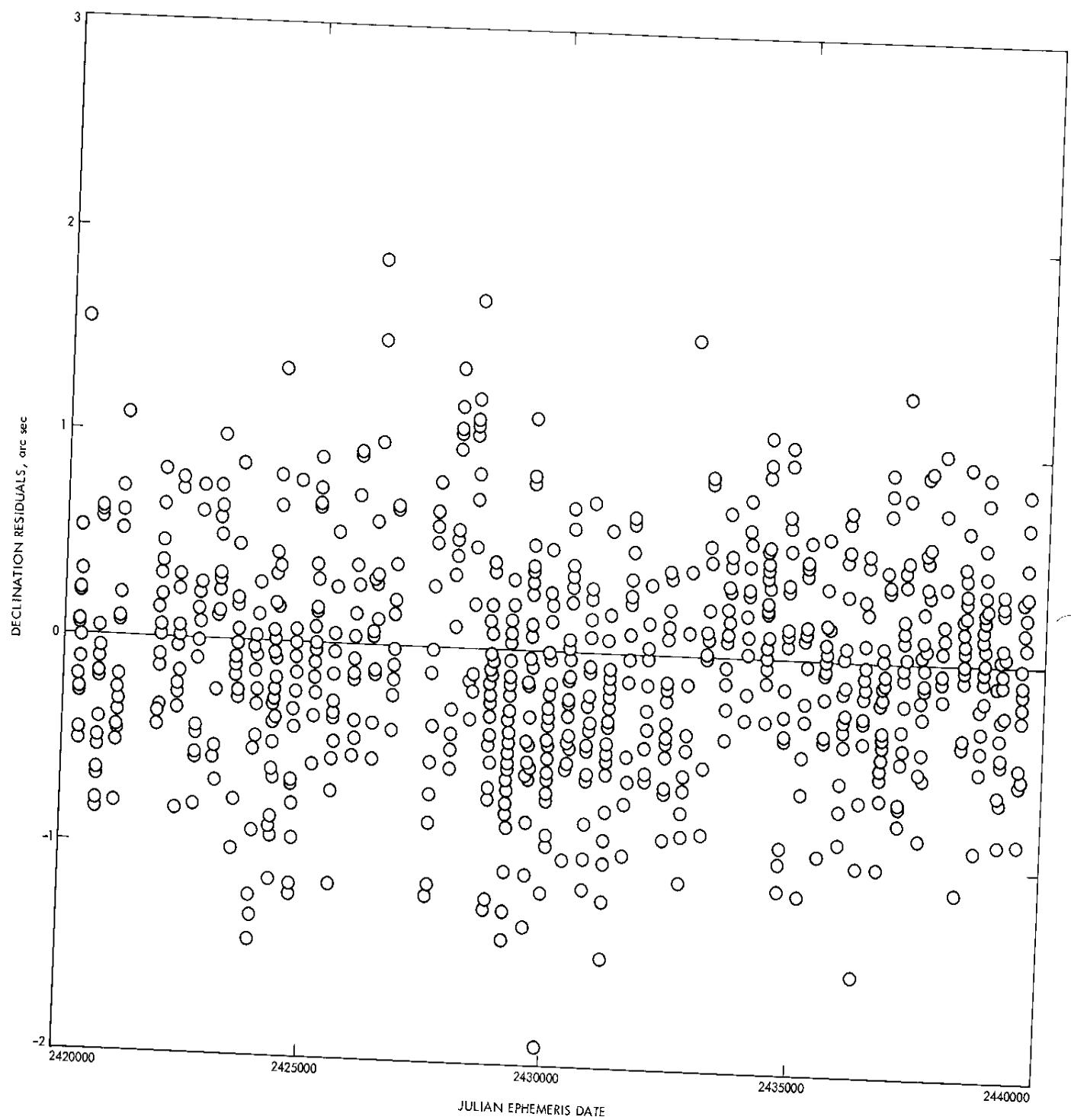


Fig. 10. Declination residuals—Jupiter.

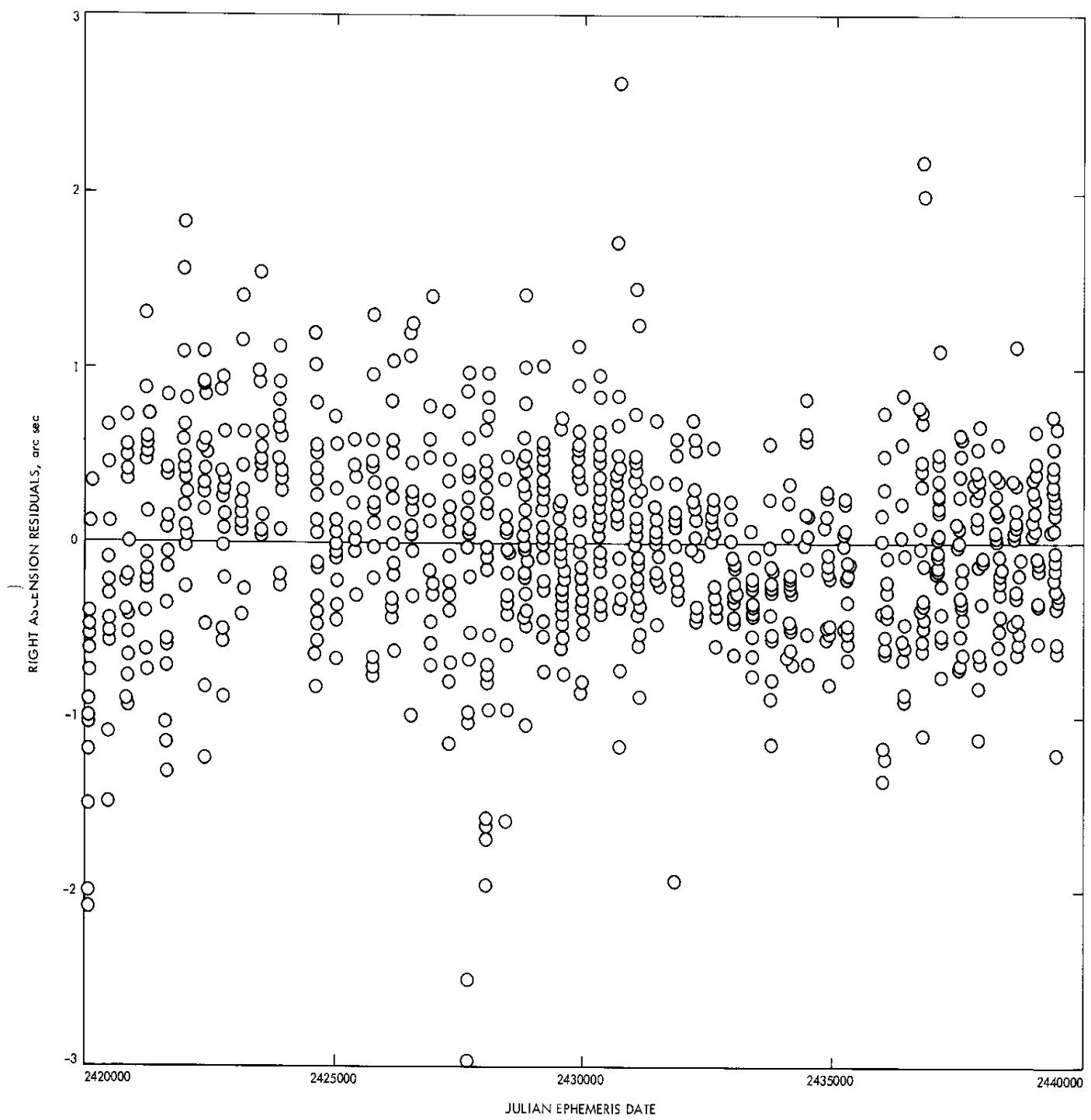


Fig. 11. Right ascension residuals—Saturn.

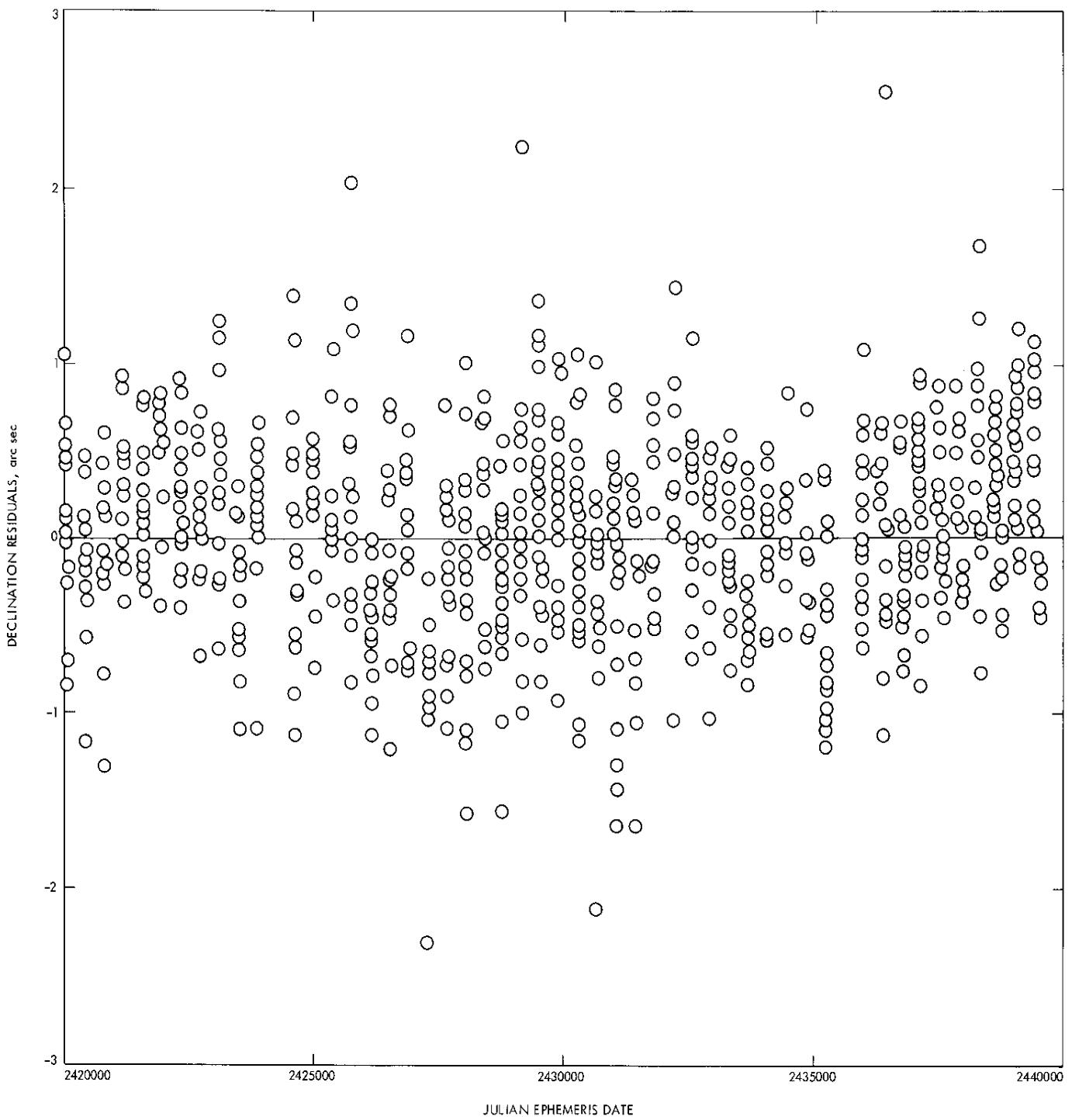


Fig. 12. Declination residuals—Saturn.

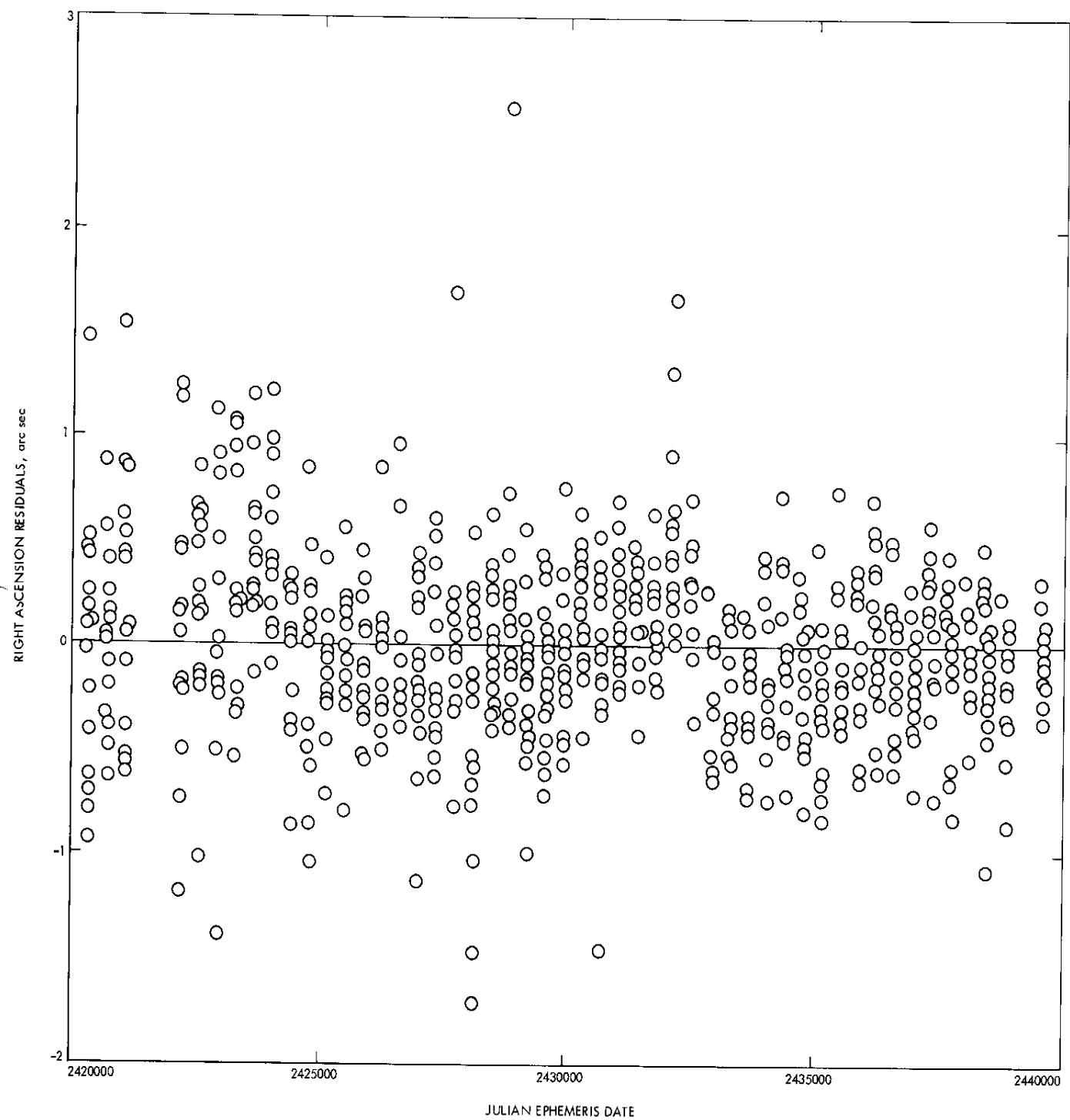


Fig. 13. Right ascension residuals—Uranus.

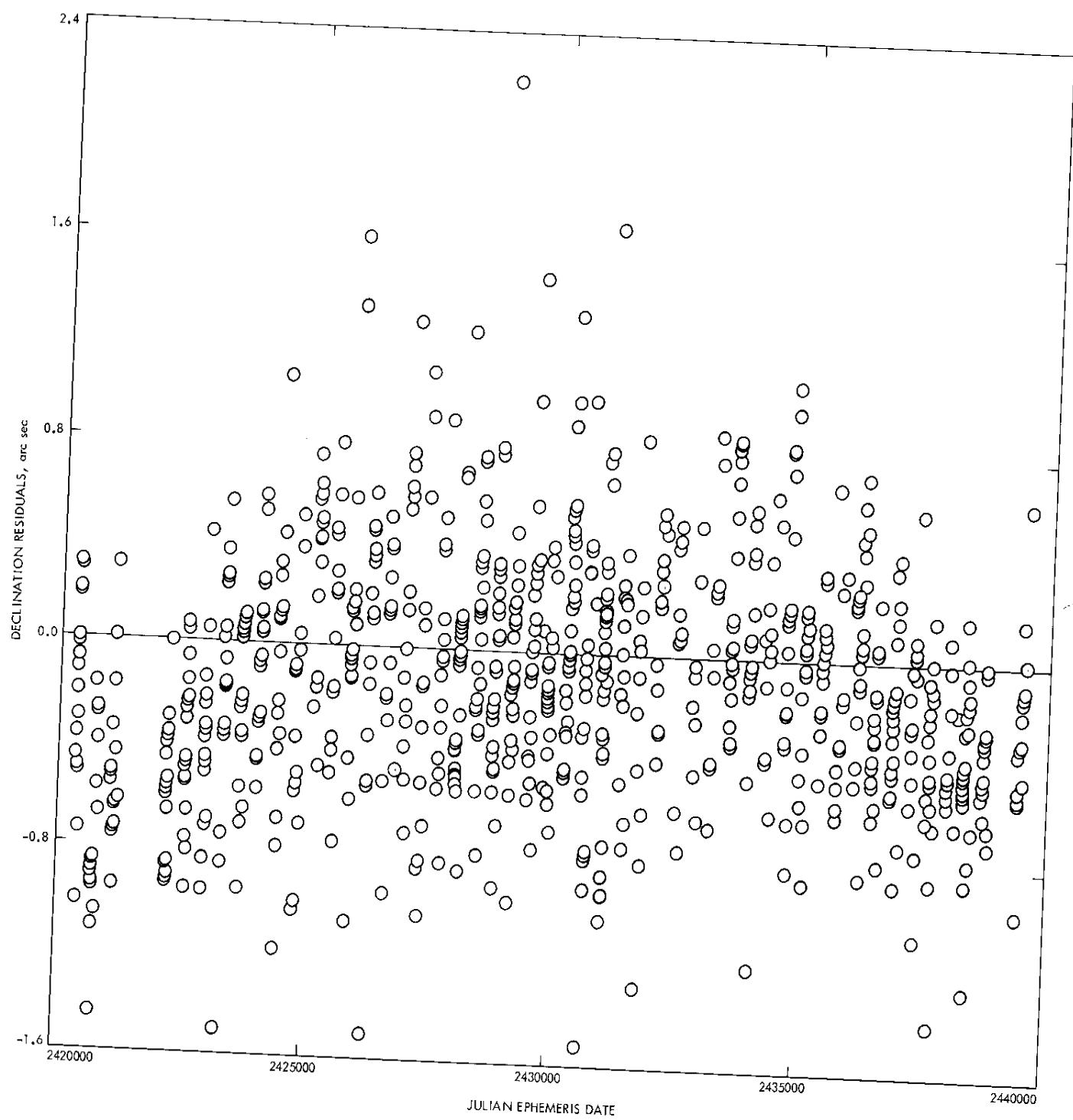


Fig. 14. Declination residuals—Uranus.

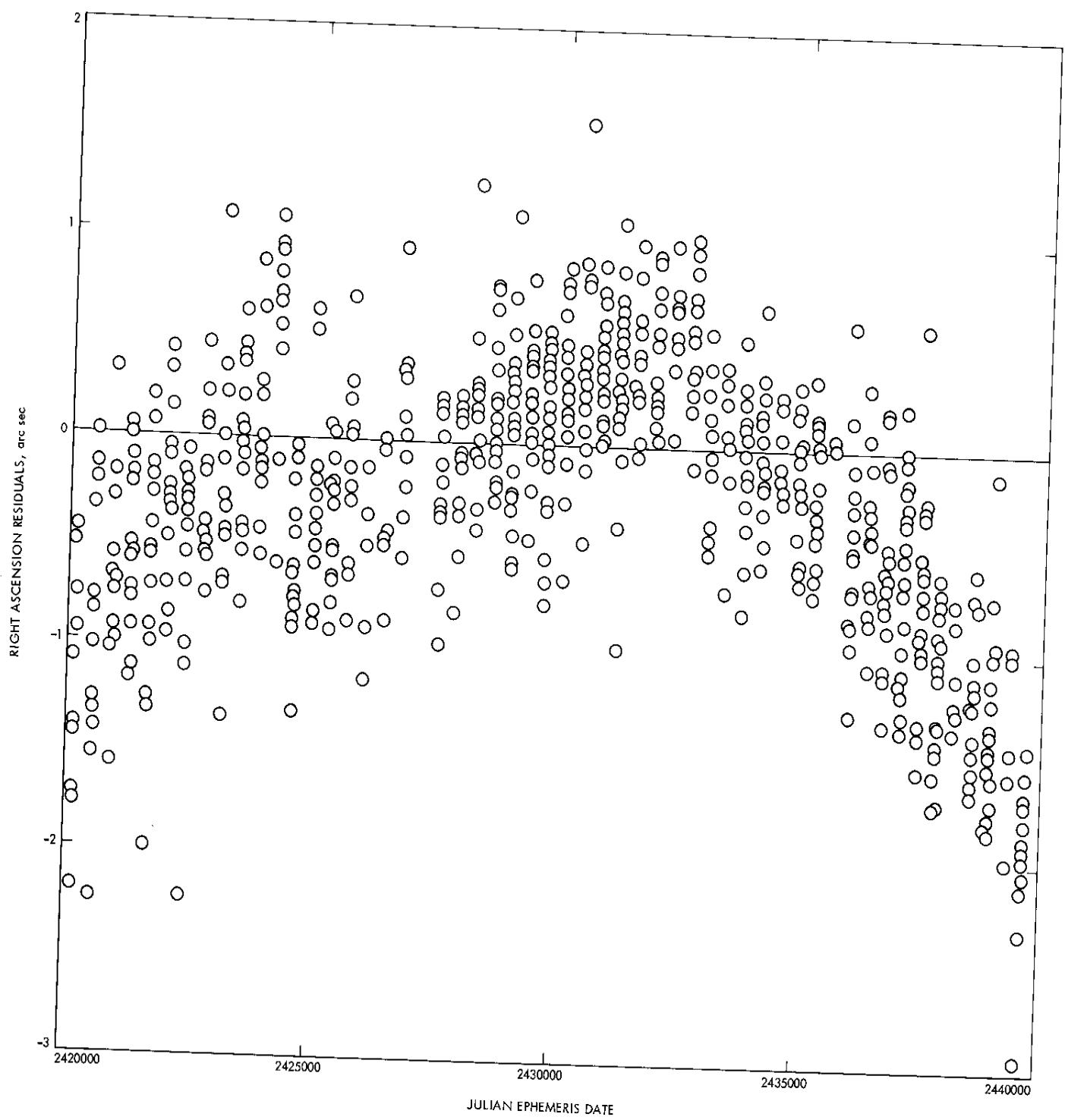


Fig. 15. Right ascension residuals—Neptune.

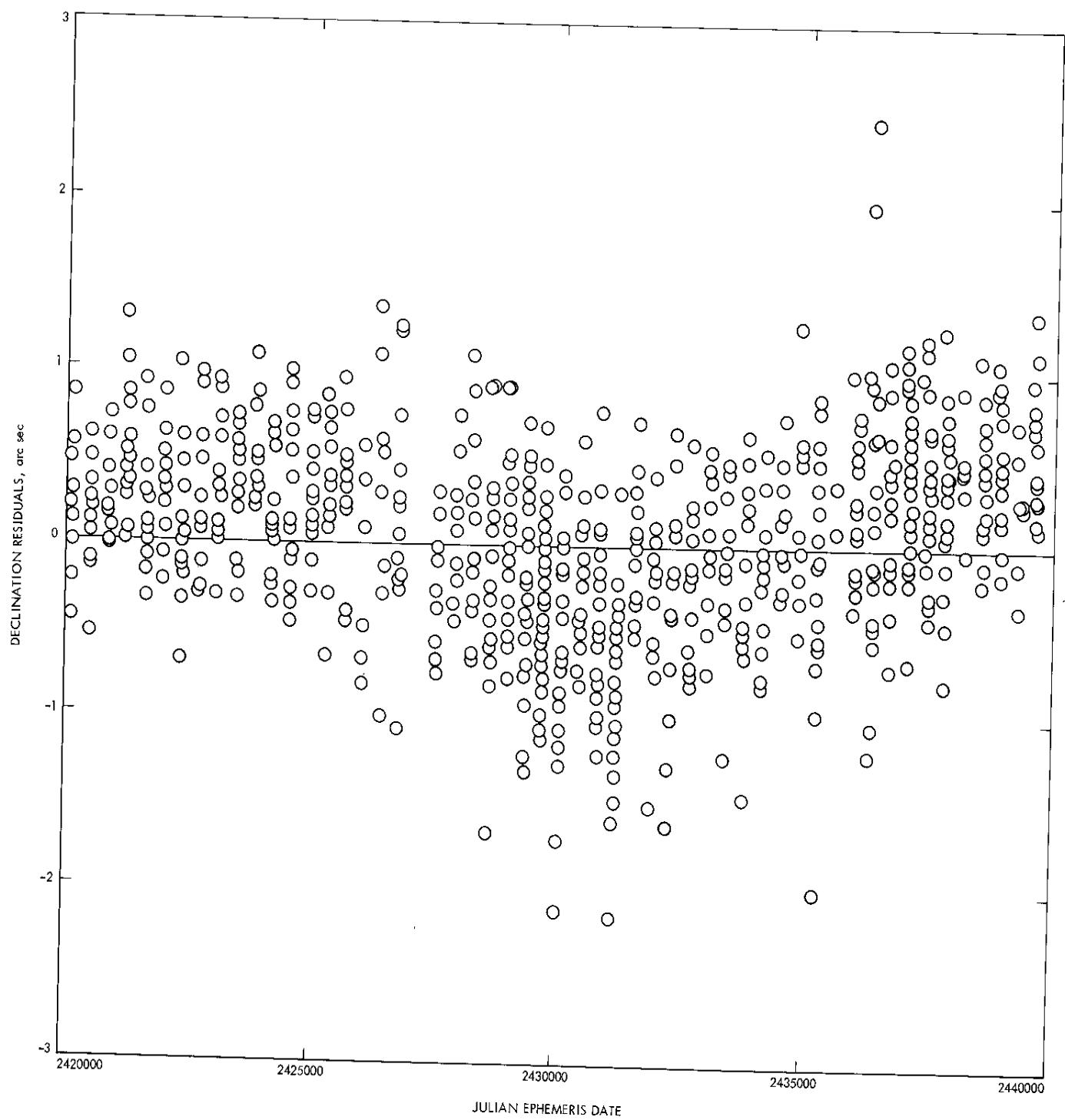


Fig. 16. Declination residuals—Neptune.

Appendix A

JPL Ephemeris Tape Format, Type 50

The JPL Ephemeris Tape Format, Type 50, contains two information records at the beginning of each tape followed by the data records. The record format may be described as follows:

- (1) The first record of each tape contains 24 BCD words written in binary. These 24 words serve to describe the general nature of the information on the tape.
- (2) The second record of each tape contains the following information in the order listed:
 - (a) Number of bodies on tapes = 10.
 - (b) A floating point 50, which denotes the Type 50 format.
 - (c) Initial Julian date for which data are provided.
 - (d) Final Julian date for which data are provided.
 - (e) Step size of the logical data record = 8.0 days.
 - (f) Ten pairs of numbers. The first number of the pair denotes the body in increasing order out from the Sun, with a zero used for lunar data. The second number of each pair is the step size of data provided for that body.
- (3) The JPL Ephemeris Tapes contain data in buffered and overlapped 8-day logical records. The end points of the 8-day span are repeated as the first points of the succeeding 8-day record. This format allows ease of handling by the interpolation program.

The format for the JPL Ephemeris Tape records is listed in Table A-1. All data, with the exception of those for nutations, are double precision, so that the total record size is 1863 words. The step size for lunar data and nutations is $\frac{1}{2}$ day. Mercury data are given in 2-day steps, and all other data in 4-day steps.

The Julian date is the epoch (Ephemeris Time, ET) of the start of the data record. Lunar positions and velocities are referred to the geocentric equatorial rectangular reference frame of the mean equator and equinox of 1950.0 = JD 243 3282.423. They are expressed in units called "earth radii" and "earth radii"/mean solar day. Planetary positions and velocities are referred to the

heliocentric equatorial rectangular frames of 1950.0, and are expressed in units of AU and AU/mean solar day.

The conversion of position and velocity tabulations to laboratory units, such as kilometers and kilometers per

Table A-1. Ephemeris tape record format

Word in record	Date ^a
0	Julian Date
2	Mercury: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by four more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by four more velocity points
182	Venus: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by two more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by two more velocity data points
290	Earth-moon barycenter: Same as Venus
398	Mars: Same as Venus
506	Jupiter: Same as Venus
614	Saturn: Same as Venus
722	Uranus: Same as Venus
830	Neptune Same as Venus
938	Pluto: Same as Venus
1046	Moon: $X, d^2X, d^4X, Y, d^2Y, d^4Y, Z, d^2Z, d^4Z$ Followed by sixteen more position data points $\dot{X}, d^2\dot{X}, d^4\dot{X}, \dot{Y}, d^2\dot{Y}, d^4\dot{Y}, \dot{Z}, d^2\dot{Z}, d^4\dot{Z}$ Followed by sixteen more velocity data points
1658	Nutations: $\Delta\Psi, d^2\Delta\Psi, d^4\Delta\Psi, \Delta\varepsilon, d^2\Delta\varepsilon, d^4\Delta\varepsilon$ Followed by sixteen more nutation data points $\Delta\dot{\Psi}, d^2\Delta\dot{\Psi}, d^4\Delta\dot{\Psi}, \Delta\dot{\varepsilon}, d^2\Delta\dot{\varepsilon}, d^4\Delta\dot{\varepsilon}$ Followed by sixteen more nutation rate data points
1862	Check sum

^aWhere d^2 and d^4 are defined as in Eq. (A.1).

Table A-2. Maximum magnitude of K th difference of quantities tabulated

K	Mercury	Venus	Earth-moon barycenter	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Moon	$\Delta\psi$	Δt	Rad		
													AU	AU	
0	0.410E-00	0.725E-00	0.100E-01	0.165E-01	0.544E-01	0.951E-01	0.182E-02	0.280E-02	0.304E-02	0.630E-02	0.914E-04	0.481E-04	0.10E-02	0.510E-06	
1	0.674E-01	0.811E-01	0.599E-01	0.582E-01	0.306E-01	0.233E-01	0.150E-01	0.125E-01	0.126E-01	0.745E-01	0.202E-06	0.384E-07	0.106E-07	0.384E-07	
2	0.109E-01	0.911E-02	0.103E-02	0.348E-03	0.193E-03	0.538E-04	0.142E-04	0.497E-05	0.488E-05	0.916E-05	0.10E-01	0.888E-07	0.238E-07	0.106E-07	0.384E-07
3	0.270E-02	0.103E-02	0.348E-03	0.983E-04	0.113E-05	0.153E-06	0.159E-07	0.704E-08	0.755E-08	0.124E-08	0.124E-08	0.124E-08	0.124E-08	0.124E-08	0.124E-08
4	0.701E-03	0.117E-03	0.236E-04	0.560E-05	0.101E-07	0.221E-08	0.198E-08	0.198E-08	0.198E-08	0.188E-08	0.188E-08	0.188E-08	0.188E-08	0.188E-08	0.188E-08
5	0.300E-03	0.138E-04	0.199E-05	0.325E-06	0.147E-08	0.142E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08	0.143E-08
6	0.129E-03	0.166E-05	0.161E-06	0.633E-07	0.227E-08	0.227E-08	0.227E-08	0.227E-08	0.227E-08						
7	0.833E-04	0.225E-06	0.205E-07	0.340E-07	0.101E-07	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08	0.412E-08
8	0.507E-04	0.372E-07	0.337E-07	0.803E-08	0.791E-08	0.791E-08	0.791E-08	0.791E-08	0.791E-08						
9	0.422E-04	0.869E-08	0.138E-07	0.142E-07	0.140E-07	0.140E-07	0.140E-07	0.140E-07	0.140E-07						
10	0.328E-04	0.533E-08	0.207E-07	0.275E-07	0.273E-07	0.273E-07	0.273E-07	0.273E-07	0.273E-07						
11	0.323E-04	0.692E-08	0.343E-07	0.492E-07	0.489E-07	0.489E-07	0.489E-07	0.489E-07	0.489E-07						
12	0.299E-04	0.122E-07	0.516E-07	0.964E-07	0.956E-07	0.956E-07	0.956E-07	0.956E-07	0.956E-07						
13	0.335E-04	0.181E-07	0.910E-07	0.177E-06	0.177E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06	0.174E-06
14	0.354E-04	0.337E-07	0.142E-06	0.343E-06	0.340E-06	0.340E-06	0.340E-06	0.340E-06	0.340E-06						
15	0.437E-04	0.534E-07	0.260E-06	0.635E-06	0.624E-06	0.624E-06	0.624E-06	0.624E-06	0.624E-06						
AU/day		AU/day		AU/day		AU/day		AU/day		AU/day		AU/day		Rad/day	
0	0.338E-01	0.203E-01	0.175E-01	0.145E-01	0.764E-02	0.588E-02	0.376E-02	0.313E-02	0.313E-02	0.149E-02	0.102E-05	0.407E-06	0.102E-05	0.102E-05	0.102E-05
1	0.548E-02	0.228E-02	0.119E-02	0.126E-02	0.612E-03	0.432E-04	0.134E-04	0.326E-05	0.124E-05	0.122E-05	0.183E-01	0.178E-06	0.775E-07	0.178E-06	0.178E-06
2	0.136E-02	0.258E-03	0.870E-04	0.246E-04	0.283E-06	0.391E-07	0.402E-08	0.182E-08	0.186E-08	0.247E-08	0.493E-07	0.215E-07	0.215E-07	0.215E-07	0.215E-07
3	0.353E-03	0.293E-04	0.590E-05	0.140E-05	0.254E-08	0.589E-09	0.515E-09	0.515E-09	0.515E-09	0.520E-09	0.618E-08	0.618E-08	0.618E-08	0.618E-08	0.618E-08
4	0.153E-03	0.344E-05	0.498E-06	0.814E-07	0.802E-09	0.604E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09	0.603E-09
5	0.654E-04	0.416E-06	0.140E-07	0.784E-08	0.107E-08	0.107E-08	0.107E-08	0.107E-08	0.107E-08	0.107E-08	0.171E-08	0.172E-08	0.172E-08	0.172E-08	0.172E-08
6	0.426E-04	0.564E-07	0.140E-06	0.534E-08	0.251E-08	0.203E-08	0.352E-08	0.352E-08	0.352E-08	0.203E-08	0.203E-08	0.527E-03	0.527E-03	0.769E-09	0.377E-09
7	0.261E-04	0.857E-08	0.306E-08	0.261E-08	0.681E-08	0.188E-03	0.188E-03	0.748E-09	0.395E-09						
8	0.219E-04	0.210E-08	0.394E-08	0.649E-08	0.123E-07	0.121E-07	0.121E-07	0.121E-07	0.121E-07	0.121E-07	0.121E-07	0.833E-04	0.833E-04	0.693E-09	0.693E-09
9	0.171E-04	0.159E-08	0.649E-08	0.102E-08	0.102E-07	0.237E-07	0.431E-07	0.431E-07	0.431E-07	0.431E-07	0.431E-07	0.440E-08	0.440E-08	0.249E-08	0.249E-08
10	0.170E-04	0.204E-08	0.102E-07	0.173E-07	0.431E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07	0.423E-07
11	0.159E-04	0.352E-08	0.173E-07	0.431E-07	0.431E-07	0.431E-07	0.431E-07	0.431E-07							
12	0.179E-04	0.539E-08	0.295E-07	0.835E-07	0.826E-07	0.826E-07	0.826E-07	0.467E-08	0.467E-08						
13	0.191E-04	0.983E-08	0.507E-07	0.153E-06	0.150E-06	0.150E-06	0.150E-06	0.922E-08	0.922E-08						
14	0.237E-04	0.163E-07	0.925E-07	0.298E-06	0.294E-06	0.294E-06	0.294E-06	0.349E-07	0.349E-07						
15	0.280E-04	0.297E-07	0.161E-06	0.550E-06	0.541E-06	0.541E-06	0.541E-06	0.10E-02	0.681E-07						

*Step size is 0.5 day for moon and novelties, 2 days for Mercury, and 4 days for others.

second, requires scaling by the conversion factors kilometers/AU and kilometers/“earth radius.” Conversion of planetary data from a heliocentric to a geocentric frame of reference requires specification of the earth-moon mass ratio μ to locate the earth-moon barycenter in the geocentric frame. Finally, if data are required for a particular epoch in Universal Time (UT), the time correction $\Delta t_q = ET - UT$ must be specified.

Interpolation

The JPL ephemeris (format type 50) contains modified second and fourth differences computed as follows:

$$\begin{aligned} d_j^2 &= \delta_j^2 + a_{26} \delta_j^6 + a_{28} \delta_j^8 \\ d_j^4 &= \delta_j^4 + a_{46} \delta_j^6 + a_{48} \delta_j^8 \end{aligned} \quad (\text{A.1})$$

where

$$\begin{aligned} a_{26} &= -0.013120 & a_{28} &= 0.004299 \\ a_{46} &= -0.278269 & a_{48} &= 0.068489 \end{aligned}$$

These modified differences are intended to facilitate the use of Everett's fifth-order interpolation formula which may be written as

$$\begin{aligned} y(t_j + sh) \cong P(s) &= y_j F_0(1-s) + d_j^2 F_2(1-s) \\ &+ d_j^4 F_4(1-s) \\ &+ y_{j+1} F_0(s) + d_{j+1}^2 F_2(s) \\ &+ d_{j+1}^4 F_4(s) \end{aligned} \quad (\text{A.2})$$

where

$$\begin{aligned} F_0(s) &= s \\ F_2(s) &= [(s-1)(s)(s+1)]/6 \\ F_4(s) &= [(s-2)(s-1)(s)(s+1)(s+2)]/120 \end{aligned}$$

Equation (A.2) is to be used only with $0 \leq s \leq 1$, in which case, the truncation error can be shown to be bounded as follows:

$$|y - P| \leq \sum_{k=6}^9 b_k M_k + b_{10} \hat{M}_{10} \quad (\text{A.3})$$

where

$$\begin{aligned} M_k &= \max |\delta^k| \\ \hat{M}_k &= h^k \max \left| \frac{d^k y}{dt^k} \right| \\ b_6 &= 8.35 \times 10^{-7} \\ b_7 &= 8.99 \times 10^{-6} \\ b_8 &= 3.05 \times 10^{-7} \\ b_9 &= 3.48 \times 10^{-6} \\ b_{10} &= 2.40 \times 10^{-4} \end{aligned}$$

The quantities of M_k are given in Table A-2 for $k = 0, 1, \dots, 15$ as computed from DE19B. The quantity \hat{M}_{10} has not been computed directly because of the difficulty of computing $d^{10} y/dt^{10}$. However, since $h^{10} (d^{10} y/dt^{10}) = \delta^{10} - (5/12) \delta^{12} + \dots$, (Ref. 19), we will use M_{10} as an approximation to \hat{M}_{10} .

With \hat{M}_{10} replaced by M_{10} , Eq. (A.3) has been evaluated, using the data given in Table A-2, and the resulting interpolation error bounds are listed in Table A-3.

Table A-3. Bound for truncation error when using fifth-order Everett interpolation formula^a

Body	Position	Velocity
Mercury	8890.00 AU	4420.00 AU/day
Venus	4.73 AU	0.62 AU/day
Earth-moon barycenter	5.19 AU	2.50 AU/day
Mars	6.74 AU	5.77 AU/day
Jupiter	6.64 AU	5.72 AU/day
Saturn	6.64 AU	5.72 AU/day
Uranus	6.64 AU	5.72 AU/day
Neptune	6.64 AU	5.72 AU/day
Pluto	6.64 AU	5.72 AU/day
Moon	10100.00 earth radii	14500.00 earth radii/day
$\Delta\psi$	0.46 rad	1.16 rad/day
$\Delta\varepsilon$	0.23 rad	0.58 rad/day

^aAll entries have been multiplied by 10^{12} ; step size is 2 days for Mercury, 0.5 day for moon, $\Delta\psi$, and $\Delta\varepsilon$, and 4 days for all others.

Appendix B

Description of FORTRAN IV Ephemeris Reading Subroutine READE

It should be noted that the format of the ephemeris tapes in DE 69 is exactly the format of DE 19; hence, any subroutine used to read DE 19 may be used without modification to read DE 69. The following subroutine system has been submitted to COSMIC for secondary distribution.

DOUBLE PRECISION AU, RE, TPD, EMRAT,
TABOUT, NUT, JED, TSEC

CALL READE (JED, TSEC, IERR)

IF (IERR .NE. 0) GO TO [error procedure]

I. Identification

- (1) READE read, interpolate, and translate JPL Ephemeris.
- (2) Program language: FORTRAN IV.
- (3) Machine: IBM 7094, UNIVAC 1108.
- (4) C. L. Lawson (JPL) and J. E. Ekelund (Planning Research Corp.), June 13, 1966.

The parameters in CETBL1 and CETBL2 and the parameters JED and TSEC must be set by the user before calling READE. READE will place its output in CETBL4 and will set the error flag IERR and may modify the flag ICW. The parameters are as follows:

Parameter	Description
AU, RE, TPD	These three parameters determine units of the output quantities. The planetary ephemerides are recorded in AU and in AU per ephemeris day. The lunar ephemeris is recorded in "earth radii" and in "earth radii" per ephemeris day. The nutation parameters are recorded in radians and radians per ephemeris day. The user must set: AU = number of output linear units in an AU RE = number of output linear units in an "earth radius" TPD = number of output time units in an ephemeris day.
EMRAT	Ratio of the mass of the Earth to the mass of the moon. This ratio is used to locate the relative position of the Earth-moon barycenter.
ICW	Flag indicating the status of arrays into which READE reads ephemeris tape records. The user must set ICW = 1 before the first CALL to READE and should generally leave ICW alone thereafter.

II. Purpose

This subroutine is to be used to obtain ephemeris data from a JPL Ephemeris Tape. The data will be interpolated to the Julian Ephemeris Date given by JED + TSEC/86400. The position and velocity vectors may be translated to provide the position and velocity vectors of any requested set of bodies relative to any requested central body.

III. Usage Part 1 (Basic Features)

A JPL Ephemeris Tape must be mounted on FORTRAN Unit 12. The tape format must be Type 50 (see Appendix A).

The user's program must contain the following statements:

COMMON/CETBL1/AU, RE, TPD, EMRAT

COMMON/CETBL2/ICW, ICENT, IREQ (13)

COMMON/CETBL4/TABOUT (6, 12), NUT (4)

Parameter	Description	Parameter	Description												
ICENT	<p>Index of body to be used as central body relative to which coordinates of requested bodies will be given. The indexes are:</p> <table> <tr><td>1 Mercury</td><td>5 Jupiter</td><td>9 Pluto</td></tr> <tr><td>2 Venus</td><td>6 Saturn</td><td>10 Sun</td></tr> <tr><td>3 Earth</td><td>7 Uranus</td><td>11 Moon</td></tr> <tr><td>4 Mars</td><td>8 Neptune</td><td></td></tr> </table> <p>(Note that earth-moon barycenter is not a permissible center.)</p>	1 Mercury	5 Jupiter	9 Pluto	2 Venus	6 Saturn	10 Sun	3 Earth	7 Uranus	11 Moon	4 Mars	8 Neptune		IERR	<p>Error flag set by READE:</p> <ul style="list-style-type: none"> 0 No error 1 ($JED + TSEC/86400.D0$) is smaller than first date on ephemeris tape 2 ($JED + TSEC/86400.D0$) is greater than last date on ephemeris tape 3 IREQ (J) is not 0,1, or 2 for some J 4 ICENT is not 1,2, ..., or 11 5 ICW is not 1, 2, or 3.
1 Mercury	5 Jupiter	9 Pluto													
2 Venus	6 Saturn	10 Sun													
3 Earth	7 Uranus	11 Moon													
4 Mars	8 Neptune														
[IREQ (J), J = 1,13]	<p>IREQ (J) specifies the type of output desired for body J.</p> <p>IREQ (J) = 0 means no output</p> <ul style="list-style-type: none"> = 1 means position only = 2 means position and velocity <p>The body numbers are assigned as given above for ICENT with the addition of 12 for earth-moon barycenter and 13 for nutation parameters.</p>														
{[TABOUT(I,J), I = 1,6], J = 1,12}	<p>Output coordinates. The first index runs through $x, y, z, \dot{x}, \dot{y}$ and \dot{z} in that order. The second index is the body number.</p>														
[NUT (I), I = 1,4]	<p>Output values of the nutation parameters:</p> <p>NUT (1) = $\Delta\psi$ = Δ longitude</p> <p>NUT (2) = $\Delta\epsilon$ = Δ obliquity</p> <p>NUT (3) = time derivative of $\Delta\psi$</p> <p>NUT (4) = time derivative of $\Delta\epsilon$.</p>														
JED, TSEC	<p>Taken together these two parameters specify the epoch of ephemeris time at which ephemeris data is desired.</p> <p>The epoch is $ET = JED + (TSEC/86400.D0)$.</p> <p>Any combination of values of JED and TSEC such that ET falls within the time span of the ephemeris tape is permissible. Highest resolution in interpolation will be obtained if JED is an exact binary number representing a Julian date close to the epoch of interest ET.</p>														

IV. Usage Part 2 (Other Features)

Besides the COMMON blocks mentioned, there are other COMMON blocks used by READE and GETTAP which may be of interest to the user:

COMMON/CETBL3/TAB3(0829), NUTAT(204), CKSUM
COMMON/CETBL5/BIVECT(6,13)
COMMON/CETBL9/JD1, TDAY, JDIF, IERR1
COMMON/REC1/REC1 (24)
COMMON/REC2/TBODY, TYPE, AJD, BJD, STEP, DUM20(20)
DOUBLE PRECISION TAB3, BIVECT, JD1, TDAY, JDIF
REAL NUTAT
INTEGER CKSUM

The standard 1863 word data record from an ephemeris tape is read by GETTAP into TAB3, NUTAT, and CKSUM.

BIVECT is working space for READE. On exit from READE, BIVECT contains interpolated and scaled, but not translated, ephemeris coordinates. The body numbering is not exactly the same as in TABOUT.

CETBL9 is used for communication between READE and GETTAP.

GETTAP reads the first two identification records of an ephemeris tape into REC1 and REC2, respectively. REC1 is a 144-character BCD identification text. REC2 contains 25 single precision floating point numbers. Of these two records, only the three items AJD, BJD, and STEP are used by READE and GETTAP.

The flag ICW has three permissible values:

Value	Description
1	Means GETTAP must rewind the ephemeris tape and read records 1 and 2 and the first data record before beginning to search for the requested epoch.
2	Means GETTAP can immediately begin to search for the requested epoch since records 1 and 2 have already been read into REC1 and

Value	Description
2 (contd)	REC2 and the last data record read from tape is in CETBL3. GETTAP always sets ICW = 2 after reading a data record.
3	Means REC1 and REC2 have been preserved, but CETBL3 has not (possibly due to OVERLAY) and, thus, GETTAP must read one data record before beginning to search for the requested epoch.

V. Subroutines Used

The FORTRAN IV SUBROUTINE, GETTAP, is used to position the tape and read the correct data record into CETBL3. All I/O is done via standard FORTRAN IV statements.

Appendix C

DE 69 Constants

The following table lists constants for DE 69.

Velocity of light	299 752.5 km/s
	Radii
Moon	1738 km
Mercury	2441
Venus	6053
Mars	3376
Jupiter	71350
Saturn	60400
Uranus	23800
Neptune	22300
Pluto	7200
Sun	696 000

Appendix D

Nominal Value Input Cards

Table D-1 presents the nominal value input cards.

Table D-1. Nominal value input cards

Body	AU			AU/Day		
	X	Y	Z	\dot{X}	\dot{Y}	\dot{Z}
Moon	1.957201476459375D-03	-1.601313108959806D-03	9.684816460553743D-04	-4.58407593648413D-04	-2.786992359772400D-04	-1.706976322327463D-04
Earth-Moon-bary-center	6.388223239672001D-01	-7.234668700684017D-01	-3.137194324577663D-01	1.308702468621249D-02	9.880583281228748D-03	4.284450687694985D-03
Mercury	-3.472828490907576D-01	-2.538198004029557D-01	-1.002522097205557D-01	1.164349789102359D-02	-1.7968225663786652D-02	-1.081910535895070D-02
Venus	-2.729262059304316D-01	-6.191876072511641D-01	-2.61788085725560D-01	1.820072423467568D-02	-6.590520902680456D-03	-4.14466068370773D-03
Mars	-1.043273791584276D-00	1.149610170700971D-00	5.556918002442636D-01	-1.028578013130965D-02	-7.076373218558543D-03	-2.972113161620146D-03
Jupiter	-4.241144808148452D-00	-3.149104334834158D-00	-1.247301166271148D-00	4.626302582644397D-03	-5.059629126080921D-03	-2.283657425358879D-03
Saturn	6.459617061053484D-00	6.101128619727081D-00	2.243375059274648D-00	-4.252230932057857D-03	3.55268583257749D-03	1.653567450141698D-03
Uranus	-1.814313887576205D-01	-2.460514498777027D-00	-8.21692903049754D-01	5.261848130241593D-04	-3.735781938971764D-03	-1.644315967838234D-03
Neptune	-1.53078110025404D-01	-2.435404000527554D-01	-9.591123470954914D-00	2.693366882765193D-03	-1.429427158965292D-03	-6.534123487881678D-04
Pluto	-3.031628335965546D-01	-1.792426075828660D-00	8.62025335954401D-00	3.986115845958216D-04	-3.146654477732543D-03	-1.114235223116397D-03

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			0285			154372426700	60426050341	176342637004	604363202600	603333656343	124777777777	177174576773					
			0337			754377777777	577537012535	602560727534	45367023377	174041277531	22462000000	60121427221	17505353623556				
			0385			106616422500	604260507531	231477777777	6012500574041	602500574041	600221605777	173744072631	320000000000	601226507420			
			0433			153231013260	60436300000	175054057405	475675471100	173556013716	070660000000	601226374240	001071110461	17476260153			
			0481			275267777777	177174621434	536202035237	674612771270	176053677470	531624020000	60326762046	463777777777	577403054312			
			0525			475774476514	177174643104	323240000000	177174643104	126460663207	602500452154	225277071377	173644071561				
			0577			404206235300	1773364752035	335651116201	17505257566	411523060740	173550412255	510540000000	601230525356				
			0625			260400000000	601233572422	174741151627	103705641100	173443346762	162570000000	57740277341	475303436200	60431045010			
			0673			107544527655	174741151627	567777777777	577421151142	570714654445	176175311456	777536257400	603515014632				
			0765			477777777777	577536443654	674612771270	176053677470	531624020000	60326762046	463777777777	577403054312				
			0817			452736416256	177247676352	340346340000	603526424572	367777777777	577421050262	512471726050	176175431652				
			0865			153152352600	603521642113	023777777777	577536351500	71215007361	176054011665	740460066000	60362744754				
			0913			133777777777	5774403151403	013612213124	176247676464	177330400700	607005641100	57740277341	477706226556	603515014632			
			0961			516274704000	603437302100	593335462000	603530636044	047777777777	577536257400	7775264000	603515014632				
			1005			545144370000	6036350514462	547777777777	177064700611	707107266015	603026764132	562615612777	17377647377				
			1057			231140000000	600637430457	572713664663	174750235273	124226540000	173162053173	020000000000	601005576041				
			1105			146055322000	174645214236	245233644000	604321511711	337577777777	177065020460	404660066000	60362642754				
			1153			373114556777	173741124351	525330000000	60637467250	5213634643	174744737224	415427072000	17740714020				
			1201			403000000000	6010055652006	02330456147	17464475730	774344751000	173440524727	317740000000	17706514020				
			1249			4636260322132	6030262604315	155522000777	173574244456	400300000000	606373526111	406716702455	17474746431				
			1287			114541014000	173563035473	253100000000	601005726064	636402477265	174644531261	232431741000	173455045726				
			1345			107300000000	577412430201	573372517174	175747267362	373011620000	603507340366	613777777777	57723727625				
			1393			653220661044	17606041435	663534332000	603530326641	577777777777	57740744261	2717732660123	175751423543				
			1401			675542310000	603637426125	467741252411	57741252411	526110176410	1757472040423	6016024630000	603537142563				
			1485			037777777777	577237270416	606015231537	000371000003								
FILE	0001	REC	0006	CH	1512												
			0001			00037100004	123606667403	17606057743	354374740000	603535067123	737777777777	577407431246	713540243119				
			0045			175751442140	376446040000	603700221454	257777777777	577412602121	321631164705	175747116250	513446570000				
			0097			603625357055	677737777777	577237262570	402171274635	176060075206	23562666000	603610153576	137777777777				
			0145			577407416246	645735537037	175751457567	265745140000	603713157417	237777777777	177073736005	631141412254				
			0193			603316110741	116432717777	17377613116	600400000000	601021412460	443351511464	174373651332	132164100000				
			0241			173162673203	655400000000	601123701272	342354252403	174273673011	272251430000	604321547674	470277777777				
			0289			177073747655	265412362027	6033131712321	476571217777	173741070102	62032000000	601021472531	407071470223				
			0337			174367232516	332414740000	173574054356	152000000000	6033131364363	570144517777	173574062516	274100000000				
			0385			173444106743	713300000000	177073761507	561102325163	603311364363	570144517777	173574062516	274100000000				
			0433			601021552620	217531546455	174363277060	734336560000	173563063104	323560000000	601124024376	523320510371				
			0481			174264325415	610370350000	173455100570	734060000000	577721256436	103645356531	175261436316	122333100000				
			0525			603507407575	223377777777	577720777453	046511713646	175751356177	713014340000	603530671654	557777777777				
			0577			577322140374	547042655031	175641756050	367463300000	603700000000	603700000000	577777777777	514032631351				
			0625			175260515075	346434350000	175641756050	674777777777	577207777453	265112171642	175751400043	277777777777				
			0673			603535521762	337777777777	577322137606	342773203337	175641750230	731101340000	603701202653					

ARUN DBH011, JPLEP45, READE, STBL, TBLN/1, VCR/2120 : USE READE TO GET COORDINATES

BASE,T 10.1,03200 . D-09 TYPE 50 REQUIREMENTS

JPL Ephemeris data program

(use READE to get points)

See pages 26-28 of 'JPL Development Ephemeris Number 69' for description of this program.

8FCR, IS MAIN.MAIN
CYCLE ONE COMPILED BY 1502 SITE-E ON 07 JAN 73 A 15:29:26.

MAIN PROGRAM

STORAGE USED: CODE(1) DATA(4) DATA(1) DEBUG: PLANK COMM(2) 00000

COMMON BLOCKS:

0003	CETBL1	000010
0004	CETPL2	000017
0005	CETBL4	000230
0006	CETBL5	000234
0007	REC1	000030
0010	REC2	000031

EXTERNAL REFERENCES (BLOCK, NAME)

0011	REARE
0012	NINTPS
0013	NWDUS
0014	NIC1\$
0015	N102\$
0016	NSTOP\$

STORAGE ASSOCIMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0009	000013	1000F	0000	000017	1001F	J00U	000021	1002F	0001	000023	1256	0001	000041	1346			
0001	000002	1476	0011	000000	1516	L001	000106	1836	0001	000106	1656	0001	000120	1756			
0000	000023	2000F	0030	000025	2001F	S001	0000126	2036	0001	000140	2116	0003	0000CC	AU			
0000	0	000008	0007	000008	8C6	L006	0	000000	BTVEC	0003	0	000006	EMRAT	0000	000007	I	
0004	+	000001	0004	000000	T0W	L006	1	000005	IEPR	0004	+	000002	TRIG	0004	1	000011	K
0000	+	000012	J	000000	TPD	L006	0	000004	JED1	0000	+	000004	TPD	0005	0	000220	NUT
0003	0	000002	8F	0005	0	000000	TAB0UR	0003	0	000004	TPD	0006	0	000002	TSEC		

00101 1* DOUBLE PRECISION JED,TSEC,AU,RT,TPD,EMRAT,TABOUT(5,12),NUT(4)
00103 2* DOUBLE PRECISION BTVEC(5,13),JDI
00104 3* REAL SRF(24),S(25)
00105 4* INTEGER TERR,TCENTR,IRRA(13)
00106 5* COMMON/CETBL1/AU,RE,TPD,EMRAT
00107 6* COMMON/CETBL2/TCW,TCENTR,TSEC
00108 7* COMMON/CETBL3/TAB0UR,NUT
00111 8* COMMON/CETBL4/BTVEC
00112 9* COMMON/REC1/SCC
00113 10* COMMON/REC2/SC
00114 11* JED=24.73280*5D0
00115 12* TSEC=0.D0
00116 13* ADR1=0.D0
00117 14* REC=4.20728775D-5
00120 15* TPD=1.0D0
00121 16* TMRATE=1.30150

```

00122      17*      ICW=1
00123      18*      ICENTR=10
00124      19*      DO 16  T=1,13
00127      20*      17  TREQ(I)=2
00131      21*      CALL READ(JRC,TSEC,ZFPRI)
00132      22*      WRITE(6,1009) RCD
00140      23*      1000  FORMAT(1H1,12A6/1H ,12A6)
00141      24*      WRITE(6,1001) S
00147      25*      1001  FORMAT(5E16.8)
00150      26*      DC 20 KEL1,66
00153      27*      CALL READ(JED,TSEC,TERR)
00154      28*      JED1=JED + TSSEC*86400.0D
00155      29*      WRITE(6,1002) JED1
00159      30*      1002  FORMAT(1H1,S25.18)
00161      31*      WRITE(6,2006) ((TAOUT(I,J)*I=1,E),J=1,12)
00172      32*      2006  FORMAT(3D25.18)
00173      33*      WRITE(6,2001) NUT
00201      34*      2001  FORMAT(4D2E.18)
00202      35*      DC 30 T=1,E
00205      36*      30  DIVECT(I,10)=SWECT(I,10)/RE
00207      37*      WRITE(6,2007) (DIVECT(I,10),T=1,E)
00215      38*      TSSEC=TSSEC + 0.12500*86400.0D
00216      39*      20  CONTINUE
00220      40*      STOP
00221      41*      END

```

END OF COMPILEATION:

NO DIAGNOSTICS.

AFORITS GETTP4, GETTP4
CYCLE 700 COMPTLCS BY 1201 575-3 0N 07 JAN 73 AT 12:23:56Z

SURVEYING SETTING ENTER PCTC 11/12/22

COMMON BLOCKS

0003	CETBL2	00017
0004	CETBL3	007507
0005	CETBL9	000007
0006	REC1	000200
0007	REC2	000031

EXTERNAL REFERENCES (BLOCK, NAME)

0010	NREW
0011	NRBUE
0012	NICIG
0013	NICIG
0014	NBSPE
0015	NERR38

卷之三

0001	00013C	133C	0001	000041	1416	0001	000064	193C	0001	000071	157C				
0001	000104	75L	0001	000011	4L	0001	000120	40L	0001	000016	5L				
0001	00013S	FOL	0001	000020	6L	0001	000154	60L	0001	000072	64L				
0001	000205	70L	0007	00002	AJS	0007	00003	BJS	0004	000750	CXSUM				
0007	000006	DUMZG	0002	000001	TCNT	0003	1	60000	ICW	0005	1	000000	TERP1		
0000	000021	INPS	0003	000002	IREG	0005	1	000010	IS	0000	0	000003	JCF		
0005	0	000004	JTF	0004	2	000013	JTG	0005	0	000000	JCI	0000	0	000011	JFWD
0004	1	003172	NUTAT	0006	2	000000	RECI	0007	0	000000	PEC2	0005	0	000004	SJDF
0000	0	000011	SPUR	0007	1	000004	STEP	0004	3	000000	TAD3	0007	0	000000	TEODY

```

00101          14*      3
00101          15*      C
00101          16*      C * COMMON BLOCK *ETC13 * 
00101          17*      C TABZ S29 DOUBLE PREC. WORD BUFFER TO ACCOMMATE J.D. AND EPHemeris. C
00101          13*      C NUTAT 204 SINGLE PREC. WORD BUFFER TO ACCOMMATE NUTATION DATA.
00101          19*      C CKSUM 15. WORD FOR CHECKSUM.
00101          20*      C
00101          21*      C THE COMMON BLOCK *ETC13 * IS FOR COMMUNICATION
00101          22*      C BETWEEN *DEF13 AND *GETR21.
00101          23*      C REFERENCE JULIAN *THE MERRIS DATE.
00101          24*      C DAY OF EPHemeris TIME EAST JCI.
00101          25*      C JDF DIFFERENCE IN DAYS BETWEEN REQUESTED DATE AND INITIAL
00101          26*      C DATE OF CURRENT EPHemeris TAPE RECORD.
00101          27*      C IERR1
00101          28*      C JENO ERROR
00101          29*      C 1=EJED+TSEC/86400, JDI LESS THAN FIRST DATE
00101          30*      C ON TAPE
00101          31*      C 2=JED+TSEC/86400, JDI GREATER THAN LAST DATE
00101          32*      C ON TAPE
00101          33*      C
00101          34*      C * COMMON BLOCK *REC13 * 24 PCD WORDS OF EPHemeris TAPE IDENTIFICATION
00101          35*      C * COMMON BLOCK *REC21 929 WORDS OF EPHemeris TAPE IDENTIFICATION
00101          36*      C * COMMON BLOCK *REC25 929 WORDS OF EPHemeris TAPE IDENTIFICATION
00101          37*      C * COMMON BLOCK *REC25 929 WORDS OF EPHemeris TAPE IDENTIFICATION
00101          38*      C * COMMON BLOCK *REC25 929 WORDS OF EPHemeris TAPE IDENTIFICATION
00101          39*      C * COMMON BLOCK *REC25 929 WORDS OF EPHemeris TAPE IDENTIFICATION
00101          40*      C TYPE TYPE OF EPHemeris TAPE. THIS IS NOT USED.
00101          41*      C AJD SINGLE PREC. INITIAL JULIAN DATE OF DATA.
00101          42*      C EJD SINGLE PREC. INITIAL DATE OF FINAL DATA RECORD.
00101          43*      C STEP STEP SIZE OF LOGICAL DATA RECORD.
00101          44*      C COMMON/CETBL3/TICK, TENT, *REC13)
00104          45*      C COMMON /CETBL3/ TAB3(829), NUTAT(204), CKSUM
00105          46*      C COMMON/CETBL3/JCI, TODAY,JDT, IERR1
00106          47*      C COMMON/REC13/REC21, REC25
00107          48*      C READ REC2(25)
00110          49*      C DOUBLE PRECISION TAB3, JDT, JDF,
00111          50*      C DOUBLE PRECISION JDI, TODAY,JDF,JDC
00112          51*      C DOUBLE PRECISION JDI, TODAY,JDF,JDC
00113          52*      C EQUIVALENCE (JFWN, SJFWN), (JDF, SJDF), (REC2, REC21), (JDIC, SJDIC),
00114          53*      C DATA IM/20/
00115          54*      C
00116          55*      C IERR1=0
00117          57*      C
00122          58*      C IF(IOW-1)4,5,2
00125          59*      C IFC(IOW-3)35,7,4
00126          60*      C RETURN
00127          61*      C ASSIGN 7 TO LCC
00130          62*      C REWIND IN
00131          63*      C READ(IM)REC1
00137          64*      C GET IC LCC, (7, JDI)
00145          65*      C JDF=EJC+STEP
00146          66*      C
00147          67*      C JDT=AJC
00150          68*      C DSTEP=STEP
00150          69*      C
00150          70*      C

```

ON TO (E,35,7), IOW

GET01400
GET01500
GET01600
GET01800
GET01900
GET02000
GET02100
GET02200
GET02300
GET02400
GET02500
GET02600
GET02700
GET02800
GET02900
GET03000
GET03100
GET03200
GET03300
GET03400
GET03500
GET03600
GET03700
GET03800
GET03900
GET04000
GET04100
GET04200
GET04300
GET04400
GET04500
GET04600
GET04700
GET04800
GET04900
GET05000
GET05100
GET05200
GET05300
GET05400
GET05500
GET05600
GET05700
GET05800
GET05900
GET06000
GET06100
GET06200
GET06300
GET06400
GET06500
GET06600
GET06700
GET06800
GET06900
GET07000

```

00150    71*   C
00151    72*   30 READ(UNIT)TAB3          *NUTAT,CKSUM
00164    73*   ICW =2
00155    74*   35 JDIF=(JD1-TAB3(1))+TDAY
00166    75*   IF(SJDIF)60,40,37
00171    76*   JDIF=JDIF-DSTER
00172    77*   ZF(SJDIF)40,4L,5P
00172    78*   C
00172    79*   C
00172    80*   C
00175    81*   40 RETURN
00175    82*   C
00175    83*   C
00175    84*   C
00176    85*   51 LEFT(DAY •LE • JDF-JD1) GC TO 52
00200    86*   TERR=2
00201    87*   RETURN
00202    88*   52 JDF=JDF-DSTER
00203    89*   IF(SJDIF)30,TU,5
00205    90*   55 READ(UNIT)TAB3(1)
00211    91*   C
00211    92*   C
00211    93*   C
00211    94*   C
00212    95*   50 JFWB=JDIF-JDF+TDAY
00213    95*   TERR(SJFWB)32,54,54
00216    97*   62 TERR=1
00217    98*   63 RETURN
00217    99*   C
00217    100*  C
00217    101*  C
00220    102*  C
00220    103*  C
00220    104*  C
00220    105*  C
00222    106*  C
00223    107*  C
00223    108*  C
00223    109*  C
00223    110*  C
00224    111*  C
00225    112*  C
00230    113*  C
00231    114*  C
00232    115*  C

      70 BACKSPACE IM
      TERR(SJDIF)74,75,3P
      JDIF=JDF+DSTER
      GC TO 70
      END

      ASSIGN 30 TO LOG
      GO TO 6
      RMAINC AND REAR FORWARD
      PARSED ACCE
      GET10900
      GET11000
      GET11100
      GET11200
      GET11300
      GET11400
      GET11500

```

END OF COMPILATION: NC DIAGNOSTICS.

AFORIS READ-E, PAGE
CYCLE 000 COMPLETED BY 1201 575-5 ON 07 JAN 72 AT 15:29:31.

SUBROUTINE READ ENTRY POINT R01027

STORAGE USED: C00E(1) 001643; DATA(1) 010244; BLANK COMM(1) 000000

COMMON BLOCKS:

0007 CETBL1 000101
0004 CETBL2 000117
0005 CETBL3 000507
0006 CETBL4 000230
0007 CETBL5 000234
0010 CETBL6 000007

EXTERNAL REFERENCES (BLOCK, NAME)

STORAGE	ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)
0001	000032 10L
0001	000256 172L
0001	000361 205L
0001	0004975 272L
0001	0006424 310L
0001	0006442 376L
0001	0006445 404L
0001	000676 4064L
0001	000732 4088L
0001	000752 4275L
0001	000753 4375L
0000	000162 1P RAY
0000	000173 1C3
0000	1 000174 1RAY
0000	1 000102 1VEL
0000	1 000176 1CASE
0000	1 000200 KC
0000	1 000156 MAXPL
0000	1 000130 PAT
0005	2 000000 TAPZ
0000	L 000006 AFLAS
0011	GETTAP
0012	NERD2\$
0013	NEPR3\$
0001	000034 1476
0001	000055 20L
0001	000403 220L
0001	000515 240L
0001	000463 3176
0001	000542 4020L
0001	000581 4043L
0001	000701 4069L
0001	000737 4092L
0001	001000 4429
0003	0 000006 ERAT
0004	T 000184 TRCDY
0000	I 000003 TPER1
0000	I 000172 ICET1
0000	I 000223 INJPS
0000	I 000154 19
0010	D 000004 JDIF
0010	D 000000 JDI
0000	T 000165 KER
0000	T 000161 LUNAR
0000	T 000115 MOENT
0000	T 000201 M1
0003	2 000002 R5
0003	2 000163 SAVE
0000	D 000152 TEMP
0002	D 000004 TPD

00103 1 * 0 READ-E

R010, INTERPOLATE, TRANSLATE JPL EPHEMERIS

RDE00100

RDE00200

RDE00300

RDE00400

00101 2* C SUBROUTINE READ(EJD, TSEC, TPER) 1965 SEPT 15
00101 3* C J.-E. SKJELUND, MECH SCIENTIFIC CORP., 1965 MAR 17
00101 4* C C.L. LAWSON, JPL, 1966 MAR 17


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00101 52* 1 POSITION
00101 53* 2 POSITION AND VELOCITY
00101 J RUNS FROM 1 TO 11 AS FOLLOWS..
00101 64* 1 MERC 5 JUP 9 PLUTO
00101 55* 2 VENUS 6 SAT 10 SUN
00101 67* 3 EARTH 7 URANUS 11 MOON
00101 53* 4 MARS 8 NEP 12 ERTH-MN-PLATYCENTER
00101 69* C * COMMON BLOCK GETBLK *
00101 70* C TAB3 S29 DOUBLE PREC. WORD SUFFI TO ACCOMMODATE J-D. AND EPHEMERIS. RDE0620
00101 71* C NUTAT 204 SINGLE PREC. WORD SUFFI TO ACCOMMODATE NUTATION DATA. RDE0630
00101 72* C CKSUM 15.7 WORD FOR CHECKSUM. RDE0640
00101 73* C ** THE FOLLOWING ITEMS ARE OUTPUT THROUGH COMMON ***
00101 74* C * COMMON BLOCK CETEL4 *
00101 75* C TABOUT * PLANETARY AND LUNAR OUTPUT. SCALED AND
00101 76* C TRANSLATED WITH RESPECT TO CENTER. RDE0650
00101 77* C TABOUT (I,J) CONTAINS OUTPUT FOR
00101 78* C BODY NO. J. (1.LE. J .LE. 10)
00101 79* C THE INDEX I TRENTEES CCMPONENTS AS FOLLOWS..
00101 80* C 1=XX 2=Y 3=Z
00101 81* C 4=XZOT 5=SYOT 6=ZDCT
00101 82* C NUTAT OUTPUT
00101 83* C NUT(1)=DELTA LONGITUDE
00101 84* C NUT(2)=DELTA ELLIPTICITY
00101 85* C NUT(3)=TIME DERIVATIVE OF NUT(1)
00101 86* C NUT(4)=TIME DERIVATIVE OF NUT(2)
00101 87* C * COMMON BLOCK SETEL5 * RDE0660
00101 88* C BIVECT( , ) WORKING ARRAY. CONTENTS ARE INTERPOLATED
00101 89* C AND SCALED OUT. NOT TRANSLATED. 1ST INDEX RUNS
00101 90* C OVER X,Y,Z,XDOT,YDOT,ZDOT AS IN TABOUT
00101 91* C BUT 2ND INDEX IS DIFFERENT AS FOLLOWS..
00101 92* C ECOTS 1 THRU 5 ARE HELIOCENTRIC.
00101 93* C 1 MEPC 5 JUP 3 PLUTO
00101 94* C 2 VENUS 6 SAT 10 MOON REL TO EARTH
00101 95* C 3 EARTH 7 URANUS 11 EARTH-MN REL TO EARTH
00101 96* C 4 MARS 8 NEP 12 EARTH-MN REL TO MOON
00101 97* C 98* C 13 SATE 4032+
00101 99* C
00101 100* C THE COMMON BLOCK *GETBLK* IS FOR COMMUNICATION
00101 101* C BETWEEN *DEEP* AND *SETBL*. AJ, PTYPE, EMAT
00101 102* C COMMON /GETBL1/
00101 103* C COMMON/GETBL2/TODAY,ICENT,TREF(13)
00101 104* C COMMON /GETBL3/TAB3(S29),NUTAT(204),CKSUM
00101 105* C COMMON/GETBL4/TABOUT(12),NUTAT(204),CKSUM
00101 106* C COMMON /GETBL5/ BIVECT(5,13)
00101 107* C COMMON/GETBL6/JD1,TODAY,JDATE,TEMP
00110 108* C LOGICAL NFLAG
00111 109* C INTEGER KREG(12),MCNT(11),ML(2),JFCT(11),IFCS(11),TVEL(11)
00112 110* C REAL NUTAT,CTR(11)
00113 111* C DOUBLE PRECISION AU,R,THDAT,TPD,TAD,BIVECT,TABOUT,NUT
00114 112* C DOUBLE PRECISION JD1,TCAY,JDATE,JED
00115 113* C DOUBLE PRECISION TSEC,RYAT,FAC,U(2,3),C,TEMP
00116 114* C
00117 115* C DATA STR/ 2,13*4,0,2*5,5/
00121 117* C DATA KREG/5,5,2,2,5*4,3,1/
00123 118* C

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00125          119*
00127          DATA WCENT/15,15,0,0,15,10,5/
00131          120*
00131          DATA M/21,0,10,11,0,12,10,0,12,0,3,3,0,0,0,3,0,13,13,0,0,0/
00135          121*
00135          122*
00135          * IPOS /42,0,0,21,145,200,254,318,362,416,470,524,1/
00135          * .IVEL /47,119,173,227,231,335,328,443,457,677,103/
00131          123*
00131          124*
00134          125*
00135          C   JD=JED
00135          126*
00135          C   TODAY=SEC*FAC
00135          127*
00135          C   CALL SETTAP
00136          128*
00136          C   IF(IERRI .NE. 0) GO TO 5000
00143          131* IFFICIENT .GE. 1 .AND. ICENT .LE. 11) OR TO 10
00143          132* IERR1=4
00144          133* GO TO 5000
00145          134* 10 CONTINUE
00145          C   135*
00146          136*      SET JREOM TO CONTROL INTERPOLATION
00146          137*      DO 20 T=1,10
00151          138*      T=PI*(T)
00153          139*      IERPRI=7
00154          140*
00155          141*      00155      JREQ(1)=TREQ(1)
00155          142*      MAXPL=JREQ(1)
00157          143*      00157      JREQ(2)=TREQ(12)
00160          144*      DO 24 T=2,10
00161          145*      00161      MAXPL=MAXD(MAXPL,JREQ(1))
00164          146*      00164      MAXEM=MAXU(JREQ(12),JREQ(11))
00166          147*      00166      MAXALL=MAXU(MAXPL,MAXEM)
00167          148*      00167      IFFICIENT=.EQ.=.NOT. TCENT.EQ.=.11) OR TO 28
00170          149*      00170      CENTER TO NOT EARTH OR MOON
00170          C   150*
00170          151*      00170      10=MON,3=ERTHM
00172          152*      00172      JREQ(1)=MAXALL
00173          153*      00173      JREQ(3)=MAXU(JREQ(3),MAXEM)
00174          154*      00174      JREQ(1)=MAXALL
00175          155*      00175      00175      C   156*
00175          157*      00175      CENTER TO EARTH OR MOON
00176          158*      00176      10=MON,3=ERTHM
00177          159*      00177      20 JREQ(10)=MAXALL
00177          160*      00177      JREQ(3)=MAXPL
00200          161*      00200      30 JREQ(11)=JREQ(3)
00201          162*      00201      LUNAR=JREQ(1n)
00202          163*      00202      EBARY=JREQ(3)*3
00202          164*      00202      30 JREQ(11) IS NOW SET
00202          165*      00202      C   166*
00203          167*      00203      C   SAVED.
00204          168*      00204      DO 240 TCODE=1,11
00207          169*      00207      240=240,40
00207          170*      00207      IF(STP(TCODE).LE.=.SAVE .AND. STP(TCODE) .GE. SAVE) GO TO 165
00212          171*      00212      40 IF(STP(TCODE).LE.=.SAVE .AND. STP(TCODE) .GE. SAVE) GO TO 165
00214          172*      00214      SAVE=STP(TCODE)
00215          173*      00215      TEMP=JREQ/SAVE
00216          174*      00216      KTEMP=
00217          175*      00217      U(1,1)=TEMP-FLOAT(MK)

RDE11900
RDE12000
RCE12100
RDE12200
RDE12300
RDE12400
RDE12500
RDE12600
RDE12700
RDE12800
RDE12900
RDE13000
RDE13100
RDE13200
RDE13300
RDE13400
RDE13500
RCE13600
RDE13700
RCE13800
RDE13900
RDE14000
RDE14100
RCE14200
RDE14300
RDE14400
RDE14500
RDE14600
RDE14700
RDE14800
RDE14900
RDE15000
RDE15100
RCE15200
RDE15300
RDE15400
RDE15500
RDE15600
RDE15700
RDS15800
RDE15900
RDE16000
RDE16100
RDE16200
RDE16300
RCE16400
RDE16500
RDE16600
RDE16700
RDE16800
RDE16900
RDE17000
RDE17100
RDE17200
RDE17300
RDE17400
RDE17500

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00220      176*   IF(U(1,1)*161,165,1C1
00223      177*   IC1 CONTINUE
00224      178*   U(2,1)=I•DO-U(1,1)
00225      179*   DC 1E3 IJ=1,2
00230      180*   U(TU,3)=U(TJ,1)*U(TU,1)
00231      181*   U(TU,2)=U(TJ,3)-1•SU/6•D1
00232      182*   U(TU,3)=U(TJ,3)-4•DO/20•SU
00234      183*   IF(TBODY-10) 159,167,220
00237      184*   167 GOTO
00240      185*   CC TC 172
00241      186*   169 GOTO
00243      187*   1C1=1
00244      188*   172 IF(U(1,1))237,201,203
00245      189*   19n*   191,192
00250      190*   203 ISER2=IGET1+§
00251      191*   193*   CC 204 IGET=IGET1,ISER2+3
00254      194*   BIVECT(ICI,ZBODY)=
00254      195*   C*(U(2,1)*(TAB3(IGET )+
00254      196*   U(2,2)*(TAB3(IGET + 1) +
00254      197*   U(2,3)*(TAB3(IGET + 2))+*
00254      198*   U(1,1)*(TAB3(IGET + 3)+*
00254      199*   U(1,2)*(TAB3(IGET + 10)+*
00254      200*   U(1,3)*( TAB3(IGE +11))) 1
00255      201*   204 IC1=IC1+1
00257      202*   CC TC 205
00260      203*   201 IC2=IC1+2
00261      204*   202 T=IC1,TC2
00264      205*   203 T=IGET1+IGET1+?
00265      206*   202 TGET1=TGET1+?
00267      207*   205 CONTINUE
00270      208*   JREG(TBODY)=JREG(TBODY)-1
00271      209*   207 IF(TBODY>240,240,207
00274      210*   207 IGET=TCCL(TBODY)+KK*§
00275      211*   207 IC1=4
00276      212*   C=C/TPE
00277      213*   CC TC 209
00277      214*   C
00277      215*   C
00277      216*   C
00300      217*   220 C=1.50
00301      218*   221 IC1=1
00302      219*   222 IGET2=TGET1+?
00303      220*   223 IF(U(1,1))223,226,228
00304      221*   228 DC 230 IGET=IGET1,IGET2+3
00307      222*   NUTT(ICI)
00312      223*   NUTT(ICI)
00312      224*   C*(U(2,1)*(NUTT(IGET )+
00312      225*   U(2,2)*(NUTT(IGET +1) +
00312      226*   U(2,3)*(NUTT(IGET +2))+*
00312      227*   U(1,1)*(NUTT(IGET +3)+*
00312      228*   U(1,2)*(NUTT(IGET +7)+*
00312      229*   U(1,3)*(NUTT(IGET +9))) 1
00312      230*   230 IC1=IC1+1
00313      231*   CC TC 222
00316      232*   226 DO 227 IGET=IGET1,IGET2+3

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00321 233*          NUT(ICI)=C*NUTAT(ICI)
00322 234*          ICI=ICI+1
00324 235*          CONTINUE
00325 236*          JREQ(TBODY)=JREQ(TBODY)-1
00326 237*          IF(JREQ(TBODY)) 240,240,23,
00327 238*          JREQ(TBODY)=JREQ(TBODY)+KK*E
00328 239*          IGETI=IVEFL(TBODY)+KK*E
00329 240*          ICI=3
00330 241*          GO TO 222
00331 242*          227  NUT(ICI)=C*NUTAT(ICI)
00332 243*          ICI=ICI+1
00333 244*          CONTINUE
00334 245*          JREQ(TBODY)=JREQ(TBODY)-1
00335 246*          IVEFL(TBODY)+KK*E
00336 247*          IF(LUNAR) 4020,4020,4010
00337 248*          C          RESULTS ARE IN BIVECT(1,11) AND NUT(1)
00338 249*          C          NOTE: *EMRATE=EARTH MASS/MOON MASS
00339 250*          C          SET BIVECT(1,11)=EARTH CENTERED AT EARTH
00340 251*          C          SET BIVECT(1,12)=MOON CENTERED AT MOON
00341 252*          C          IMAX=LUNAR * 3
00342 253*          DO 4010 T=1,-MAX
00343 254*          C          BIVECT(1,11)=EMRAT*BIVECT(1,10)
00344 255*          C          BIVECT(1,12)=EMPAT*BIVECT(1,11)
00345 256*          C          4010  EMRAT=EMPAT+1.00
00346 257*          C          WFLAG=.FALSE.
00347 258*          C          KCENT=MCENT(1CENT)
00348 259*          C
00349 260*          C          BEGIN TRANSLATION LOOP
00350 261*          C
00351 262*          C          DO 4100 TBODY=1,12
00352 263*          C          IF(IREC(TBODY)) 4100,4100,4024
00353 264*          C          4024  IMAX=IMIN(TBODY)*3
00354 265*          C          KASE=KASE+KREC(TBODY)
00355 266*          C          K1=MI(KASE)
00356 267*          C          CC TC (4032,40340,4032,4043,4052,
00357 268*          C          * 4032,4036,4040,4048,4056,
00358 269*          C          * 4032,40370,4076,4040,4022,
00359 270*          C          * 4084,4088,4088,4064,4080),KASE
00360 271*          C          KASE=15
00361 272*          C
00362 273*          C          4023  K1=TBODY
00363 274*          C          KASE=1,7,8,11
00364 275*          C          4032  CC 4036 T=1,MAX
00365 276*          C          4036  T=1,MAX
00366 277*          C          4036  T=1,MAX
00367 278*          C          4036  T=1,MAX
00368 279*          C          4040  CC 4044 T=1,MAX
00369 280*          C          4044  T=1,MAX
00370 281*          C          CC TC 4108
00371 282*          C          KASE=4,8
00372 283*          C          4049  K2=3
00373 284*          C          30 TO 4100
00374 285*          C          KASE=5
00375 286*          C          4052  L2=11
00376 287*          C          CC TC 4000
00377 288*          C          KASE=10
00378 289*          C          4055  L2=12

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INTERPOLATION IS FINISHED

RESULTS ARE IN BIVECT(1,11) AND NUT(1)

TEST MCN REQUEST

NOTE: *EMRATE=EARTH MASS/MOON MASS

SET BIVECT(1,11)=EARTH CENTERED AT EARTH

SET BIVECT(1,12)=MOON CENTERED AT MOON

PDE23300 RDE23300
 PDE23400 RDE23400
 PDE23500 RDE23500
 PDE23600 RDE23600
 PDE23700 RDE23700
 PDE23800 RDE23800
 PDE23900 RDE23900
 PDE24000 RDE24000
 PDE24100 RDE24100
 PDE24200 RDE24200
 PDE24300 RDE24300
 PDE24400 RDE24400
 PDE24500 RDE24500
 PDE24600 RDE24600
 PDE24700 RDE24700
 PDE24800 RDE24800
 PDE24900 RDE24900
 PDE25000 RDE25000
 PDE25100 RDE25100
 PDE25200 RDE25200
 PDE25300 RDE25300
 PDE25400 RDE25400
 PDE25500 RDE25500
 PDE25600 RDE25600
 PDE25700 RDE25700
 PDE25800 RDE25800
 PDE25900 RDE25900
 PDE26000 RDE26000
 PDE26100 RDE26100
 PDE26200 RDE26200
 PDE26300 RDE26300
 PDE26400 RDE26400
 PDE26500 RDE26500
 PDE26600 RDE26600
 PDE26700 RDE26700
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 PDE27000 RDE27000
 PDE27100 RDE27100
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 PDE27900 RDE27900
 PDE28000 RDE28000
 PDE28100 RDE28100
 PDE28200 RDE28200
 PDE28300 RDE28300
 PDE28400 RDE28400
 PDE28500 RDE28500
 PDE28600 RDE28600
 PDE28700 RDE28700
 PDE28800 RDE28800
 PDE28900 RDE28900

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00410      290*    4050  K1=IACCY
00411      291*    K2=13
00412      292*    GC TC 4092
00413      293*    C
00414      294*    4054 K1=CENT
00417      295*    4069 SC 4072 T=1,TMAX
00421      296*    4072 TABOUT(T,IBODY)=BIVECT(T,V2)
00424      297*    CC TC 4160
00421      298*    C
00422      299*    4075 K2=KASE-1
00423      300*    GC TO 4100
00426      301*    C
00427      302*    4080 K1=BODY
00424      303*    C
00425      304*    4084 K2=CENT
00426      305*    GC TC 4100
00426      306*    C
00427      307*    4083 L2=CENT
00431      308*    4092 IF(WFLAG) GC TO 4100
00433      309*    K2=KASE-6
00433      310*    4093 IF(WFLAG) GC TO 4100
00433      311*    WFLAG=.TRUE.
00433      312*    C
00433      313*    C
00433      314*    C
00433      315*    FOR KASE=6
00433      316*    FOR KASE=14
00433      317*    FOR KASE=17,18
00433      318*    C
00434      319*    DO 4085 T=1,TMAX
00437      320*    4085 BIVECT(T,13)=BIVECT(I,3)-BIVECT(I,L2)
00437      321*    C
00437      322*    4100 SC 4104 T=1,TMAX
00441      323*    4104 TABOUT(T,IBODY)=BIVECT(T,V1)-BIVECT(T,V2)
00446      324*    4108 CONTINUE
00450      325*    5000 RETURN
00451      326*    C
00452      327*    END
00452      328*    C

END OF COMPUTATION:   NC DIAGNOSTICS.

@PRT,T
FURPUR 23A9-01/07-15:29

READE*TFF$ ELEMENT TABLE

C NAME          VERSION     TYPE      DATE      TIME      SEQ #      SIZE-PRE,TEXT (CYCLE WORD) PSRMODE LOCATION
MAIN          07 JAN 73 15:29:27      1         9      5      0      1      1792
RELLOCATABLE  07 JAN 73 15:29:28      2         3      3      0      1      1801
FOR SYMS      07 JAN 73 15:29:28      3         62      5      0      1      1813
RELOCATABLE  07 JAN 73 15:29:31      4         10      10      0      1      1875
FOR SYMS      07 JAN 73 15:29:35      5         176      5      0      1      1887
RELOCATABLE  07 JAN 73 15:29:40      6         35      2      0      1      2063
NEXT AVAILABLE LOCATION:  2100

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ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE EMPTY

2XGT
MAP 22-5 - 01/07-15:29

ADDRESS	LIMITS	001000 012010	040000 051000
STARTING ADDRESS	011035		
WORDS	DECIMAL	4E17 IBANK	46J5 CBANK
NSWTC\$/\$FOR			
NWEFS\$/FOR	1	001000 001021	040000 051000
NBDCVS\$/FOR	1	001022 001204	040000 051000
NFTVS\$/FOR	1	001205 001332	040000 051000
NCNVTS\$/FOR	1	001333 001355	040000 051000
NCLOSS\$/FOR	1	001356 001765	040000 051000
NBF00\$/\$FOR	1	001576 001765	040000 051000
NCTINS\$/FOR	1	001756 002270	040000 051000
NOUT\$/\$FOR	1	002271 003240	040000 051000
NBSBL\$/\$FOR	1	003341 003375	040000 051000
NRELKS\$/FOR	1	003376 003420	040000 051000
NUPDAS\$/FOR	1	003421 003456	040000 051000
NFMTS\$/FOR	1	003457 004332	040000 051000
NFTCH\$/\$FOR	1	004732 004696	040000 051000
NWALKS\$/FOR	1	004647 004763	040000 051000
NIGERS\$/FOR	1	004754 005201	040000 051000
UTINFU (COMMON BLOCK)	1	005292 006150	040000 051000
NFCHK\$/\$FOR	3	UTINFU	040000 051000
NTABS\$/FOR			
ERU\$			
NSTOP\$/\$FOR	1	006151 006210	040000 051000
NOBUFS\$/FOR	1	006311 006252	040000 051000
NINTRS\$/FOR	1	006253 006475	040000 051000
NBKSPS\$/FOR	1	006476 007154	040000 051000
NIFRS\$/FOR	1	007155 007324	040000 051000
NFTNPS\$/FOR	1	007735 007651	040000 051000
NRWND\$/\$FOR	1	007752 007732	040000 051000
NERRS\$/FOR	1	007733 010330	040000 051000
REC2 (COMMON BLOCK)			
REC1 (COMMON BLOCK)			
CETBL9 (COMMON BLOCK)			
CETBL5 (COMMON BLOCK)			
CETBL4 (COMMON BLOCK)			
CETBL3 (COMMON BLOCK)			
CETBL2 (COMMON BLOCK)			
CETBL1 (COMMON BLOCK)			
PLANKSC COMMON (COMMON BLOCK)	1	010731 011373	040000 051000
PEADE			
	0	050424 050667	040000 051000

SYSS\$*RLIBS*, LEVEL 67 01
END OF COLLECTION - TIME 0.945 SECONDS

GE TTF4	2	CETBL1	2	BLANK&COMMON
	3	CETBL2	4	CETBL2
	5	CETBL3	6	CETBL4
	7	CETBL5	8	CETBL5
MATN	1	011374 011E34	0	050670 050725
	3	CETBL2	2	BLANK&COMMON
	5	CETBL3	4	CETBL2
	7	REC2	6	REC1
	1	011635 012010	0	050727 051000
	3	CETBL1	2	BLANK&COMMON
	5	CETBL4	4	CETBL2
	7	REC1	6	CETBL5
	8	REC2	8	REC2

Y,M,D,H,M=71,12,07,05,29 ,1118
0 WITH LF 1E (1950-1970)
.10000000+02 .50005000+02 .24332805+07 .24406935+07 .80000000+01
.00000000+00 .50000000+00 .10000000+00 .20000000+01 .20000000+01
.00000000+01 .30000000+01 .40000000+01 .40000000+01 .40000000+01
.50000000+01 .40000000+01 .50000000+01 .40000000+01 .70000000+01
.40000000+01 .80000000+01 .40000000+01 .90000000+01 .40000000+01

JUL SPHERICAL • 1 N DEG TYPE 5

* 24332805000000000000+007
* 343925387129539135+000
- 845649153937539217-002
* 14295669999999999999+000
- 19893801592131692-061
- 1367894530999222931+000
- 1731579243595068478-061
- 135931482466889593+001
- 73945937871395723-002
* 33493576439655956+001
. 5585686325789769-002
- 39725996399227477+001
* 18582637472309818-002
- 10029437083289055+001
- 395525358697644613-002
* 2919449480751054695+002
* 820773636198255189-003
- 252335724363375019+002
- 131589716916531772-002
. 0000000000000000000
* 0000000000000000000
- 134244935427721502+000
- 176624207271194616-001
- 135362412575077110+000
- 1732000041498517974-001
- 166009962834132742-004
- 502769592697817794+002
-. 81300793683869432+001

* 45617007023470703-001
* 25614642531849204-001
* 64710519519622717-000
* 311715940189325714-000
* 933731044275646327+000
* 224932897164802072-002
* 943139043121187553+000
- 2472347743297041-002
- 34777219547263794+001
. 496224616492729311-002
* 227670455740752540+001
* 498135455210306890-002
- 173335274015451542+002
- 37560336087542791-003
- 771919091569122291+001
- 277637071741941-002
* 2853205687781067370+002
- 26261241282177204-002
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- 389445327306930257+001
- 10611500760640585-002
* 89379976076359405+000
- 224402591554356681-002
* 407764564442913979-004
* 243443962034247575-002
-. 906142394572378391+001

* 45617007023470703-001
* 14568237345765180-001
* 28248152726607447+000
* 255645216179904932-002
* 3874480936475828+000
* 875857040549784121-002
* 423937437310433610+000
* 415164190522683492-002
- 15721526902006078+001
* 199226806120531802-002
* 13034645911371685+001
* 19825132494457080-002
* 76081877127790606+001
- 10894392623175306-003
- 242714989352903658+001
- 11561141092456252-002
* 14444727088578825+002
- 42708145690813412-003
. 0000000000000000000
* 0000000000000000000
- 389191279239818569+000
* 761349156923574632-003
* 387457128399307496+000
- 573347550491750689-003
* 935289717585031031-007
* 174211215865676222+002
* 50338570634256696+001

- 102338542608608805-005

- 24332962500000000+007
 • 342849046887177958+000
 - 877110213818970546+002
 • 1404790949988061270+000
 - 19978319140707938+001
 • 1385538495355008C+000
 - 1731029636072280C-001
 - 137075386310c83314+001
 - 73735785877517815-002
 • 3350050179243012124+001
 • 53874295431-002
 - 8972732897625521+001
 - 185786038554441923-002
 - 100344311472957245+001
 - 3952489852223986-002
 - 29194347856023604+002
 • 826e116732339273-003
 - 26233736972702196+002
 -.1315877546502350-002
 • 00000000000000000
 - 13643311230972600+000
 - 176691549796219061-001
 - 1395270797495739+000
 - 1731485667978179652-001
 - 155775454058055-004
 • 49242712349781919+002
 - 841633916110340033+001
 • 498142515002153311-001
 • 255727561998350606-001
 • 94779037793171074+000
 • 30491098262122040-002
 • 939137752305004735+000
 - 387721837121903+000
 • 941057951873346900+000
 - 94841145722478942+002
 - 347316105322903863+001
 • 49872297070854970-002
 - 277918167921786+001
 - 49873574930480225-002
 - 17323480407711704+002
 - 375097515418202507-003
 - 771947325882+8122+001
 - 277918167921786+002
 - 205617412398373792+002
 - 2626132322052502-002
 • 00010000000000000
 • 00000000000000000
 • 00000000000000000
 • 00000000000000000
 - 1909221204045913177-002
 • 933115130535350414+000
 • 8342934920123503+000
 - 1909221204045913177-002
 - 78045607227820499-003
 • 387334517394059487+000
 - 988419757610006958-007
 • 11630462083951216385481+006
 • 49377426824701141+001
 - 3102330709966914-002
 • 145557045053924460-001
 • 282912036191600141+000
 • 2631477560090206888-002
 • 387721837121903+000
 • 422319269282514704+000
 - 415564581819245402-002
 - 157196362897051191+001
 • 13309882395494840+001
 - 198031121347214991-002
 • 76048061632165175+001
 - 10898504609557468-003
 - 242733941257274509+001
 - 1156105378047356-002
 • 1444461932225965877+002
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RUNID: DBH011 ACCOUNT: JPC04 PROJECT: RACE
LCAC 6320R 2/1 16 -1 DBH011

15:29:27

*** RUN ACCOUNT INFORMATION ***

ITEM	AMOUNT	RATE	CHARGE
CPU TIME	12 SEC	\$100.10/MIN	\$.43
CORE TIME PRODUCT	.25 KWORD SEC	\$ 4.00/KWORD/MIN	\$ 1.15
NUMBER OF TAPES	1	* .38/TAPE	\$.38
PRINTER	84 PAGES	\$.031/PAGE	\$ 2.61
TOTAL CHARGE FOR THIS RUN			\$ 4.52

*** MISCELLANEOUS INFORMATION ***
CARDS READ 432 CARDS PUNCHED 0 PAGES PRINTED 34
INITIATION TIME FOR RUN 15:29:25 ON JAN 7, 1973
TERMINATION TIME FOR RUN 15:31:12 ON JAN 7, 1973
AMOUNT REMAINING IN THIS ACCOUNT AS OF 11/06/73 \$2772

D-11597

JULIAN EPHEMERIS DATE = 2440696.5

X

Y

Z

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5 JUPITER		4.00			
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• 119-08	• 156-08	• 194-08	• 284-08	• 619-08	• 931-08
• 833+01	• 207-01	• 166-03	• 113-05	• 874-03	• 111-08
• 115-08	• 129-08	• 184-09	• 230-08	• 369-08	• 511-08
• 207+01	• 125-01	• 710-04	• 487-06	• 385-08	• 616-09
• 622-09	• 682-09	• 994-09	• 121-08	• 200-08	• 271-08
• 544+01	• 306-01	• 193-03	• 113-05	• 101-07	• 135-08
• 119-08	• 156-08	• 194-08	• 284-08	• 619-08	• 931-08
• 764-02	• 482-04	• 277-06	• 255-08	• 371-09	• 273-09
• 439-09	• 522-09	• 818-09	• 109-08	• 183-08	• 266-08
• 727-02	• 416-04	• 283-06	• 217-09	• 265-09	• 273-09
• 360-09	• 516-09	• 682-09	• 106-08	• 155-08	• 255-08
• 312-02	• 177-04	• 122-06	• 962-09	• 140-09	• 174-09
• 200-09	• 267-09	• 551-09	• 852-09	• 132-08	• 217-08
• 764-02	• 482-04	• 283-06	• 255-08	• 371-09	• 312-09
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6 SATURN		4.00			
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• 833+01	• 207-01	• 538-04	• 125-06	• 232-08	• 106-08
• 115-08	• 129-08	• 184-08	• 230-08	• 368-08	• 511-08
• 346+01	• 855-02	• 223-04	• 509-07	• 116-03	• 595-09
• 622-09	• 682-09	• 994-09	• 121-08	• 200-08	• 271-08
• 951+01	• 235-01	• 538-04	• 156-06	• 232-08	• 136-08
• 119-08	• 156-08	• 194-08	• 284-08	• 394-08	• 615-08
• 588-02	• 133-04	• 391-07	• 562-09	• 361-09	• 273-09
• 439-09	• 522-09	• 818-09	• 109-08	• 183-08	• 266-08
• 518-02	• 134-04	• 313-07	• 559-09	• 270-09	• 273-09
• 360-09	• 516-09	• 682-09	• 106-08	• 155-08	• 255-08
• 214-02	• 558-05	• 127-07	• 294-09	• 152-09	• 140-09
• 200-09	• 267-09	• 377-09	• 551-09	• 852-09	• 132-08
• 588-02	• 134-04	• 391-07	• 562-09	• 362-09	• 273-09
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• 119-08	• 156-08	• 194-08	• 284-08	• 394-08	• 619-08
• 164+02	• 150-01	• 115-04	• 159-07	• 202-08	• 106-08
• 115-08	• 129-08	• 184-08	• 230-08	• 359-08	• 511-08
• 711+01	• 660-02	• 499-05	• 710-08	• 106-08	• 595-09
• 622-09	• 682-09	• 994-09	• 121-08	• 200-08	• 271-08
• 182+02	• 150-01	• 142-04	• 152-07	• 377-09	• 551-09
• 119-08	• 156-08	• 194-08	• 284-08	• 391-07	• 818-09
• 194-09	• 284-08	• 394-08	• 619-08	• 931-08	• 154-07P
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*149+02	*183+01	*247+00	*377-01	*717-02	*172-02	*527-03	*168-03V10X0-7
*801-04	*374-04	*198-04	*113-04	*711-05	*472-05	*348-05	*259-05V10X8-15
*141+02	*174+01	*234+00	*359-01	*677-02	*165-02	*490-03	*160-03V10Y0-7
*739-04	*353-04	*182-04	*106-04	*657-05	*444-05	*318-05	*241-05V10Y8-15
*702+01	*826+00	*115+00	*162-01	*328-U2	*740-03	*237-03	*822-04V10Z0-7
*354-04	*163-04	*858-05	*492-05	*303-05	*206-05	*147-05	*113-05V10Z8-15
*149+02	*183+01	*247+00	*377-01	*717-02	*172-02	*527-03	*168-03V10W0-7
*801-04	*374-04	*198-04	*113-04	*711-05	*472-05	*348-05	*259-05V10W8-15

11 NUTAT

		STEP =					
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*481-04	*202-06	*384-07	*105-07	*304-09	*992-09	*336-09	*168-09P11Y0-7
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*000	*000	*000	*000	*000	*000	*000	P11Z0-7
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*966-06	*171-06	*458-07	*139-07	*438-08	*157-08	*726-09	*663-09V11X0-7
*122-08	*233-08	*443-08	*843-08	*152-C7	*308-07	*593-07	*113-05V11X8-15
*407-06	*776-07	*211-07	*618-U8	*193-U9	*699-09	*336-09	*287-09V11Y0-7
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*000	*000	*000	*000	*000	*000	*000	V11Z8-15
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D-11599

JULIAN EPHEMERIS DATE = 2451512.5

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333-3-11	4.93-02	1.36-02	327-03	1.52-07	645-04	4.26-04	261-04V	1X0-7
219-64	171-04	170-04	159-04	179-04	191-04	237-04	280-04V	1X8-15
259-61	543-02	559-07	353-02	114-03	654-04	236-04	255-04V	1Y0-7
177-54	164-04	140-04	150-04	149-04	178-04	200-04	260-04V	1Y8-15
19C-01	293-02	557-03	139-03	151-04	193-04	138-04V	1Z0-7	138-04V
287-05	311-05	825-05	311-05	964-05	110-04	140-04V	1Z8-15	140-04V
333-01	548-02	136-02	753-03	152-03	654-04	226-04	261-04V	1W0-7
219-64	171-04	170-04	159-04	179-04	191-04	237-04	280-04V	1W8-15
2 VENUS								
725+00	911-01	911-02	102-02	117-02	133-04	155-05	224-06P	2X0-7
340-07	822-08	508-08	854-08	104-07	171-07	289-07	496-07P	2X8-15
653+00	741-01	933-02	939-02	107-02	125-04	153-05	212-06P	2Y0-7
323-07	549-08	548-09	718-08	124-07	193-07	242-07	581-07P	2Y8-15
301+00	358-01	798-02	425-03	490-04	561-05	705-06	910-07P	2Z0-7
145-07	513-08	199-09	262-08	432-09	706-08	115-07	214-07P	2Z8-15
725+00	911-01	911-02	103-02	117-02	138-04	166-05	224-06P	2W0-7
725+00	822-08	548-08	718-08	124-07	198-07	342-07	581-07P	2W8-15
340-07	223-02	258-02	293-04	344-05	416-06	550-07	847-07P	2X0-7
203-01	149-02	200-08	328-08	556-08	922-08	166-07	281-07V	2X8-15
185-01	248-02	235-02	328-04	312-05	384-06	502-07	814-07V	2Y0-7
192-06	158-08	229-08	358-08	618-08	104-07	186-07	317-07V	2Y8-15
341-02	947-03	106-07	123-04	140-05	178-06	225-07	355-07V	2Z0-7
855-09	850-09	919-09	152-08	242-09	427-08	716-08	130-07V	2Z8-15
203-01	223-02	258-02	345-04	344-05	416-05	560-07	847-07V	2W0-7
212-02	158-08	229-09	356-08	518-05	614-07	104-07	196-07	2W8-15
3 ERTHMN								
100+01	999-01	477-02	248-03	236-04	199-05	152-06	204-07P	3X0-7
346-05	183-07	216-07	320-07	555-07	848-07	156-05	253-06P	3X8-15
922+04	974-01	942-02	305-02	234-04	162-05	159-05	215-07P	2Y0-7
258-02	119-07	193-07	302-07	503-07	822-07	141-05	245-06P	3Y8-15
404+04	275-01	195-02	132-03	102-04	704-05	592-07	773-08P	3Z0-7
445-02	599-08	901-08	150-07	229-07	401-07	322-07	114-06P	3Z8-15
100+01	599-01	477-02	348-03	275-04	169-05	159-06	214-07P	3W0-7
508-08	183-07	216-07	320-07	555-07	848-07	156-06	253-06P	3W8-15
175-01	119-02	187-04	560-05	497-05	381-07	547-05	274-06V	3X0-7
376-08	613-08	947-08	107-07	262-07	481-07	798-07	148-06V	3Y8-15
158-01	112-02	732-04	386-05	406-05	389-07	445-06	72-09V	3Y0-7
354-08	579-08	245-08	152-07	266-07	393-07	793-07	125-06V	3Y8-15
587-02	487-03	330-04	254-05	276-06	174-07	193-07	115-06V	3Z0-7
177-09	706-08	404-08	739-08	131-07	225-07	395-07	676-07V	3Z8-15
175-01	119-02	870-04	590-05	497-06	355-07	547-08	274-08V	3W0-7
376-08	513-08	347-03	167-07	266-07	481-07	798-07	148-06V	3W8-15
5 STEP								
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
6 MARS								
165+01	582-01	245-02	275-04	560-05	223-06	295-07	328-08P	4X0-7
145-08	158-08	125-08	294-08	397-08	620-08	950-08	154-07P	4Y8-15
142+01	952-01	206-02	382-04	453-05	225-05	242-07	345-08P	4Y0-7
140-08	131-08	185-08	518-08	518-08	518-08	123-07P	4Y8-15	123-07P
652+00	535-01	955-02	450-04	211-05	149-05	133-07P	163-08P	4Z0-7
672-02	692-02	106-06	124-05	201-08	176-08	704-08P	4Z8-15	704-08P
165+01	582-01	245-02	383-04	560-05	225-05	295-07	345-08P	4W0-7
158-08	284-08	397-09	620-08	950-08	154-07P	4W8-15	154-07P	4W8-15

5 SATURN		6 STEP		7 URANUS		8 STEP		9 JUPITER		10 STEP		
• 953+01	• 525-04	• 102-06	• 219-08	• 137-08	• 102-08	• 115-08P	• 6X0-7	• 115-08P	• 5X0-7	• 392-09V	• 4X0-7	
• 119-03	• 156-08	• 194-08	• 282-09	• 294-03	• 813-08	• 931-08	• 154-07P	• 5X8-15	• 154-07P	• 5X8-15	• 726-08V	• 4X8-15
• 926+01	• 206-01	• 433-04	• 123-06	• 214-08	• 105-08	• 104-08	• 926-09P	• 6Y0-7	• 926-09P	• 5Y0-7	• 356-09V	• 4Y0-7
• 115-03	• 129-03	• 184-02	• 230-08	• 359-08	• 854-08	• 864-08	• 129-07P	• 5Y8-15	• 129-07P	• 5Y8-15	• 476-08	• 476-08
• 207+01	• 125-01	• 711-04	• 489-06	• 286-09	• 616-09	• 558-09	• 514-09P	• 5Z0-7	• 514-09P	• 5Z0-7	• 865-09	• 865-09
• 522-03	• 591-09	• 984-04	• 124-03	• 200-08	• 278-08	• 457-08	• 7C4-08P	• 5Z8-15	• 7C4-08P	• 5Z8-15	• 107-08	• 107-08
• 594+01	• 380-01	• 192-07	• 113-05	• 103-07	• 141-08	• 104-08	• 115-08P	• 5W0-7	• 115-08P	• 5W0-7	• 255-08	• 255-08
• 119-03	• 156-09	• 194-09	• 233-09	• 294-03	• 619-09	• 931-08	• 154-07P	• 5W8-15	• 154-07P	• 5W8-15	• 444-09	• 444-09
• 765-03	• 482-04	• 278-06	• 259-08	• 376-09	• 273-09	• 323-09V	• 5X0-7	• 323-09V	• 5X0-7	• 145-09	• 145-09	
• 433-03	• 521-09	• 818-09	• 109-08	• 183-09	• 266-09	• 465-09	• 717-08V	• 5X8-15	• 717-08V	• 5X8-15	• 204-09	• 204-09
• 727-02	• 416-04	• 293-06	• 216-06	• 282-09	• 274-06	• 248-09	• 314-09V	• 5Y0-7	• 314-09V	• 5Y0-7	• 267-03	• 267-03
• 360-02	• 583-02	• 166-08	• 155-08	• 255-08	• 396-08	• 679-08V	• 5Y8-15	• 679-08V	• 5Y8-15	• 145-09	• 145-09	
• 312-02	• 178-04	• 122-06	• 270-06	• 158-09	• 142-06	• 139-09	• 152-09V	• 5Z0-7	• 152-09V	• 5Z0-7	• 265-02	• 265-02
• 200-02	• 267-03	• 377-07	• 531-09	• 852-09	• 122-09	• 219-08	• 353-08V	• 5Z8-15	• 353-08V	• 5Z8-15	• 194-02	• 194-02
• 765-02	• 482-04	• 283-06	• 259-08	• 376-09	• 274-09	• 312-09	• 465-09	• 722-08V	• 5W0-7	• 722-08V	• 5W0-7	
• 433-02	• 521-09	• 318-09	• 109-08	• 193-09	• 266-08	• 465-08	• 717-08V	• 5W8-15	• 717-08V	• 5W8-15	• 111-08	• 111-08

• 149+02	• 183+01	• 248+00	• 377-01	• 720-02	• 174-02	• 530-03	• 196-02V10X0-7
• 807-04	• 368-04	• 209-04	• 110-04	• 722-05	• 466-05	• 265-05V10X8-15	
• 142+02	• 174+01	• 235+00	• 359-01	• 675-02	• 489-02	• 181-02V10Y0-7	
• 736-04	• 356-04	• 181-04	• 107-04	• 647-J5	• 165-02	• 450-05	
• 712+01	• 872+00	• 117+00	• 101-01	• 332-02	• 270-03	• 316-05	• 265-05V10Y8-15
• 373-04	• 177-04	• 918-05	• 526-05	• 326-05	• 216-05	• 150-05	• 908-04V10Z0-7
• 149+02	• 183+01	• 248+00	• 377-01	• 720-02	• 174-02	• 530-03	• 192-03V10Z0-7
• 807-04	• 368-04	• 209-04	• 110-04	• 722-05	• 466-05	• 265-05V10W8-15	

11 NUTAT	S15C	=	.50				
• 903-04	• 537-06	• 885-07	• 252-07	• 703-08	• 234-08	• 807-09	• 433-09P11X0-7
• 533-09	• 102-09	• 197-09	• 383-08	• 754-03	• 148-07	• 289-07	• 570-07P11X8-15
• 481-04	• 203-06	• 294-07	• 107-07	• 313-08	• 997-06	• 357-09	• 201-09P11Y0-7
• 252-09	• 449-09	• 388-09	• 170-08	• 334-08	• 644-08	• 127-07	• 247-07P11Y8-15
• 000	• 000	• 000	• 000	• 000	• 000	• 000	• P1120-7
• 000	• 000	• 000	• 000	• 000	• 000	• 000	• P1128-15
• 903-04	• 537-06	• 885-07	• 252-07	• 703-08	• 234-08	• 807-09	• 433-09P11W0-7
• 533-09	• 102-09	• 197-09	• 383-08	• 754-03	• 148-07	• 289-07	• 570-07P11W8-15
• 108-05	• 178-06	• 505-07	• 142-07	• 466-08	• 160-08	• 700-09	• 674-09V11X0-7
• 122-08	• 225-08	• 433-08	• 820-08	• 157-07	• 293-07	• 572-07	• 1C9-06V11X8-15
• 407-06	• 722-07	• 215-07	• 524-08	• 202-08	• 702-09	• 320-09	• 318-05V11Y0-7
• 529-09	• 105-03	• 192-03	• 367-02	• 634-03	• 133-07	• 253-07	• 5C1-07V11Y8-15
• 000	• 000	• 000	• 000	• 000	• 000	• 000	• V1120-7
• 000	• 000	• 000	• 000	• 000	• 000	• 000	• C10-V11W8-15
• 108-05	• 178-06	• 505-07	• 242-07	• 456-08	• 166-09	• 701-09	• 674-09V11W0-7
• 122-08	• 225-08	• 433-08	• 820-08	• 157-07	• 293-07	• 572-07	• 1C9-06V11W8-15